



Center for High Technology Materials

Photolithography Bay Operating Procedure

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1.0 INTRODUCTION

This operating procedure provides supplemental instruction for the photolithography bay at CHTM. Reading this document **WILL NOT** replace training in the photolithography bay. Reading this document will only give the user general guidelines for equipment operation and will re-emphasize safety and cleanliness issues.

Any suggestions for changes to this document shall be made in writing to the author. This operating procedure should be reviewed at least yearly to verify that it reflects current processes. Any major change in operation will require a revision to the operating procedure. All authorized users will be notified of any changes in operating procedures. Authorized users are not to make changes to the printed copy of this document without permission of the photolithography qualifier.

2.0 TRAINING REQUIREMENTS

Since CHTM is a research facility, operating procedures and training requirements may change from time to time. All authorized users will be notified of changes in operating procedures. If training requirements change, all users will be notified and will be required to complete the new training requirements before using the equipment again. Notification of changes will be via e-mail and will be posted on the white board in the gowning area of the cleanroom.

Training is required to assure that everyone uses the equipment in the photolithography bay in a safe and proper manner. Unsafe or improper operation of the equipment affects all cleanroom users even if they do not realize or believe it does. Because all users must be trained, unsafe or improper equipment operation in the clean room will not be allowed. A messy work area is considered unsafe.

To become an authorized user you must accomplish several tasks.

- You must successfully complete your cleanroom orientation. We will not allow you to become certified to use the photolithography bay without going through cleanroom orientation.
- You must read and understand this document.
- You need to watch and understand the training videotapes.
- After reading this document and watching the video tapes you will be given a set of questions to answer regarding proper conduct in the photolithography bay. Answer these questions as thoroughly as possible and return them to one of the photolithography qualifiers right before your qualification.
- You will need to arrange for hands on training with an authorized user in your research group. If there is no authorized user in your group, you may contact another authorized user for hands on training, but do not disrupt their work. During your training period, you are not allowed to use the equipment in the photolithography bay without an authorized user with you at all times.
- After you feel comfortable operating all the equipment in the photolithography bay (we suggest operating the equipment under supervision for a minimum of 10 times) you must demonstrate your ability to operate the equipment for a photolithography qualifier.

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- After demonstrating your competence with the equipment, you may be asked additional questions, as the photolithography qualifier deems appropriate.
- When all the steps are completed, your name will be put on the authorized user list. At that point, you are considered an authorized user of the photolithography area.
- If you do not complete all steps in the training process, you are not considered an authorized user and are not allowed to use the equipment without supervision.

The training videotapes are available from Karen DeZetter, room 135. These videos are available for checkout on an as needed basis. Because many people need to watch them, the videos should be returned within 2 days of check out unless arrangements are made in advance. There is a television set and a videotape player available in the department for viewing the training videotapes.

3.0 PHOTOLITHOGRAPHY BAY RULES

There are many pieces of equipment in the photolithography bay. Most cleanroom users will need to access one or all of those pieces of equipment. Because of the large number of people using this equipment, we have developed rules of operation for the photolithography bay. These rules have been put in place to make sure that the bay is safe and that the equipment is kept functional at all times.

- Authorized users are to report unauthorized and/or unsafe use of the equipment to the cleanroom technician immediately. Equipment problems must be reported to the cleanroom technician as well. This will help keep the equipment safe and in working order for everyone.
- Use common sense when operating the equipment in the photolithography bay. Stupid or unsafe operation of the photolithography equipment will not be tolerated.
- Be courteous to the other users of the clean room. Keep your work area clean. Refill solvent wash bottles if they are less than half full. If you don't know where something is stored, ask another user. If you use up an item, replace it. If you begin using the last replacement, notify the cleanroom technician so additional stock can be ordered.
- If there is a piece of equipment that needs to be added to the photolithography bay, see the cleanroom technician and building manager to discuss plans for adding the equipment. Do not add or remove equipment from the photolithography bay without permission.
- The equipment in the photolithography bay is considered precision equipment and is very expensive, so replacement parts are also quite expensive. If it is found that you have ruined a part or piece of equipment, you or your professor will be charged for replacing the equipment or part. Here are examples of how expensive replacement parts are: the spinner chucks are approximately \$500 each, the mask holders are approximately \$1500 each and the sample chucks for the aligner are approximately \$3000 each. Not only are these parts expensive, it also takes approximately 4 months for them to arrive after ordering them. This time cannot be decreased.
- Unlabeled or improperly labeled containers will not be tolerated. At random times throughout the day, the photolithography qualifiers and the cleanroom technician will

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be touring the bay to see if there are unlabeled containers. Unlabeled containers will be thrown away. Unlabeled samples and supplies left unattended will be confiscated, and you will need to see the cleanroom technician to get them back. Toolboxes must be put away when you are finished working in the photolithography bay unless the box contains light-sensitive materials. In that case, the box can remain in the bay but must be labeled as to why it is stored there. Remember that we have a limited amount of space, do not spread out your work so there is no area for anyone else to work

- The final, but most important rule of all is to keep your work area clean. Wipe down the bench surface when you are finished using it. Clean your work area as you work. Leave the work area cleaner than when you found it. Do not leave drops of any chemical (water included) on the bench. Unclean work habits are a major cause for process failure in the cleanroom. If we all follow these simple rules, the photolithography bay will be a safer place to work.

An authorized user agrees to follow the procedures stated in this document and will inform a member of the photolithography team of any suspected malfunction or problem as soon as possible. Unauthorized users or users who do not follow these procedures will face the following consequences before being allowed to use the equipment again. Improper actions causing injury to you or others or damage to the photolithography bay equipment will move the severity of the offense up at least one category.

- If you are caught using the equipment without being an authorized user or operating the equipment improperly or unsafely, you will be barred from the clean room for at least 1 week. At the end of one week, you must ask the cleanroom technician to allow you back into the cleanroom and ask the photolithography qualifiers to allow you to use the photolithography bay again. For a period of one month, you will only be allowed to use the cleanroom during normal working hours (M-F 8am-5pm).
- A second violation of photolithography bay procedures will result in the user being barred from the cleanroom for at least 1 month. At the end of 1 month, the user must submit a written request to the cleanroom technician to be allowed back in the cleanroom and must go through photolithography bay training again. You may also be required to undergo cleanroom orientation again, at the discretion of the cleanroom technician. For a period of 2 months after undergoing retraining, you will only be allowed to use the cleanroom during normal working hours (M-F 8am-5pm).
- A third violation will result in the user being barred from the cleanroom for a minimum of 6 months. At the end of this time, your professor must request that you be re-admitted to the cleanroom. You will be required to undergo retraining for the cleanroom and the photolithography bay. For a period of 6 months after being re-admitted to the cleanroom and being retrained in photolithography, you will only be allowed to use the cleanroom during normal working hours (M-F 8am-5pm).
- A fourth offense will result in permanent denial of cleanroom access.

In return for following these procedures, the photolithography qualifiers and cleanroom technician will, to the best of their ability, keep the equipment in the photolithography

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bay in an operating condition. Because we are not in the clean room constantly, contact the cleanroom technician or photolithography qualifier with any equipment problems immediately. If we don't know about a problem, we can't fix it.

4.0 PHOTOLITHOGRAPHY QUALIFIERS

The following is a list of photolithography qualifiers and their phone numbers. When a problem is encountered, try to contact the first person on the list. Do not call qualifiers at a home phone number unless it is an **extreme** emergency.

Name	Office	Office Phone	Lab Phone	Home Phone	e-mail
Beth Fuchs	115C	272-7844	272-7863 272-7864	237-9271	Bfuchs@chtm.unm.edu
Karen DeZetter	135	272-7835	272-7863 272-7864		Dezetter@chtm.unm.edu

5.0 SAFETY NOTES

There are a wide variety of materials processed in the CHTM, so no single document can address all possible safety notes. Use common sense when operating equipment. If you notice something you perceive to be a safety hazard, do not proceed. Notify a member of the photolithography team immediately so the hazard can be addressed. As mentioned before, if we don't know something is wrong, we can't fix it.

Remember that we consider a messy work area to be an unsafe work area. Cleanroom users who repeatedly show unsafe work habits will be denied access to the cleanroom for the safety of all cleanroom users.

5.1 General Chemical Safety

Most cleanroom processes will involve chemicals in one form or another. Chemicals occur in one of three forms: gas, liquid or solid. Gaseous and solid chemicals are not normally used in the photolithography bay. In general, the following are some basic rules to follow when handling chemicals:

- Never mix chemicals together if you are unsure of what reaction will occur. Some chemicals will react violently or release poisonous fumes when mixed together.
- Be extremely careful when mixing chemicals as some of the chemical solutions used undergo exothermic reactions (they release heat) when mixed and the solution containers can become quite warm.
- Always read labels on containers and properly label your containers.
- Treat any unknown chemical as a strong acid or base until you know for sure that it isn't. Test unknown chemicals with pH paper and treat appropriately.
- Transport chemicals properly.
- Dispose of chemical wastes properly. If you do not know how to properly dispose of a chemical, ask someone!
- Do not taste or smell chemicals to determine their identity.
- Work surfaces and tools should be "wiped down" before beginning any processing

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to assure clean, contamination free work surfaces. Always use a lint-free cloth to wipe down an area.

- Always wear proper personal protective equipment and cleanroom apparel.

5.2 Liquid Chemical Safety

The most common forms of chemicals in the photolithography bay are liquid chemicals. Care must be taken to avoid accidental contact with liquid chemicals, as many of them are potentially hazardous. The liquid chemicals typically used in the photolithography bay are solvents, photoresist, photoresist developers and photoresist strippers.

- Do not mix developer and solvents.
- Work at the properly wet bench for the chemical you are using.
- Wipe up all spills and clean your work area as you go.
- Wipe developer bottles with a damp wipe after pouring.
- When carrying bottles support them from the base as well as the neck or use a bottle carrier and wear personal protective equipment as needed.
- Wash your hands with soap and water after leaving the cleanroom in case of accidental chemical exposure.

5.3 Waste Disposal

Dispose of all chemicals and used materials properly. Safe disposal of chemicals is a legal requirement. Improper chemical disposal can seriously affect you, your co-workers and other people in the city. The waste stream at UNM is monitored for improper chemical disposal and if detected, can lead to significant fines, possible cleanroom closure, and even legal action. If you do not know how to dispose of the chemicals, ask the cleanroom technician.

5.4 Ultraviolet Light

CHTM's mask aligners use ultraviolet light to expose the photoresist. The ultraviolet light used in the mask aligners is approximately 350nm to 400nm. Sunlight also contains ultraviolet waves, which can burn your skin. Most of these are blocked by ozone in the Earth's upper atmosphere. Small doses of ultraviolet radiation can be beneficial, but larger doses can cause skin cancer and cataracts. Do not look directly at ultraviolet light sources. It is possible to "sunburn" your eyes.

5.5 Thermal

The hot plates and ovens are left on all the time, so they are normally quite warm. Touching them can cause severe burns. In addition, the shields around the ultraviolet lights on the aligners become warm when the bulbs are on. Touching the shields could cause a burn.

6.0 OPERATING PROCEDURES

The photolithography bay is used at CHTM to pattern substrates for further processing. Several pieces of equipment are used in this process. Each plays an important role in photolithography. The following is a partial list of equipment in the photolithography bay:

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- Aligner
- Hot plates
- Microscope
- Ovens
- Spinner
- Wet benches

6.1 Aligners

The mask aligner is a precision piece of equipment used to selectively expose photoresist to ultraviolet light. Never force any of the adjustments. This can cause problems with the micrometers on the aligner.

It is imperative that the UV source and power supply are working properly. Check that the digital display on the front panel of the power supply to the right of the MJB-3 shows a number. This is the idle power of the mercury arc lamp. If the display is dark or does not show a number, contact one of the photolithography qualifiers. The left aligner should read 195. The right aligner should read 275.

During normal operation, the lamp is very hot. If the lamp has been shut off for any reason, it must be allowed to cool before restarting. The lamp requires a high voltage pulse to start. This pulse was designed to start a cold lamp. Starting a hot lamp with this same high voltage pulse will damage the lamp electrodes and possibly cause the lamp to explode. The lamp should be cooled for at least 30 minutes before restarting. After ignition, the lamp needs to warm up for at least 15 minutes before it is capable of producing our standard exposure intensity. The supply will also need calibration after a power outage. Photolithography qualifiers will calibrate the aligner after restarting the lamp. Do not do any exposures until the lamp has been calibrated.

During an exposure, the reading on the digital display of the power supply should be recorded in the logbook. If the equipment beeps during exposure, note the power on the digital display, stop the exposure and contact a photolithography qualifier immediately. Do not proceed and do not allow anyone else to do an exposure on that aligner. If you continue, your use privileges will be revoked. By observing this readout during exposure, the aligners proper operation can be confirmed. As the lamp ages, the amount of power required to supply the same intensity of light will increase. The system will alarm if a pre-set power is reached, indicating that the lamp must be changed before being used again.

Successful contact photolithography requires flat surfaces. In a typical contact exposure, there are eight surfaces involved in making intimate contact between the mask and the substrate. These surfaces will be shown to each user during training.

- Leveling plate
- Bottom of the chuck
- Top of the chuck
- Bottom of the substrate
- Top of the substrate

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- Bottom, patterned side of the mask
- Top side of the mask
- Bottom of the mask-holder

A scratch or bump on any one of these eight surfaces will degrade the fidelity of your printing by either interrupting vacuum or causing separation between the mask and the substrate.

Any of the stainless steel surfaces, such as the mask-holder, plate or chuck can be scratched by metal tweezers or by contact with another steel part. If you use metal tweezers, do not touch the stainless steel surfaces with your tweezers. Teflon tweezers do not normally scratch the stainless steel surfaces. Acid, bases and DI water can also corrode the stainless steel surfaces. Samples and masks should be dry before putting them on the aligner. Do not handle any of the stainless steel parts with wet gloves as this can cause corrosion too.

6.1.1 Normal Operation

1. Verify no one is using the aligner. If so, wait for that person to finish. If you are set up to use the aligner and find that you won't be ready several minutes, remove your materials and let someone else go ahead of you. If you are exposing your samples one at a time, remove your materials unless no one else is in the photolithography bay.
2. Verify your sample is not too thick. The aligners are only designed to accommodate a 2mm thick sample. If you need to expose a sample that is thicker than 2mm, contact the cleanroom staff to arrange an alternate method of exposure.
3. Select which aligner is needed.
 - a. Both aligners are set up to expose the wafer with both 365 nm and 405 nm light. Occasionally, the 200W aligner is not available for 365 nm exposures.
 - b. The 200W aligner (left side) has a +/- 10% uniformity across a 3" exposure area. If your sample is large, consider using the other aligner.
 - c. The 350W aligner (right side) has a +/- 5% uniformity across a 3" exposure area. This aligner is recommended if you need uniform exposure across a large area.
 - d. The uniformities listed above are the worst-case uniformities.
4. Select the contact mode needed.
 - a. Vacuum contact—HP mode. A vacuum is drawn between the mask and wafer before exposure. This allows the highest resolution since the gap between the mask and the wafer is minimized. The wafer chuck must be one with a vacuum gasket in order for this mode to be effective.
 - b. Standard Hard Contact—ST Mode. The vacuum holding the substrate to the chuck is switched off and nitrogen is used to press the substrate against the mask. Any wafer chuck can be used for this mode, but the ones with a vacuum gasket may make a whistling noise because of the nitrogen escaping between the gasket and the mask.
 - c. Soft Contact—ST and Soft Cont. Mode. When both ST and Soft Contact buttons are illuminated, the substrate is held to the mask just by mechanical pressure. The vacuum on the chuck remains on. This is the least precise of all the modes of exposure.

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5. Load mask onto the holder.
 - a. Loosen knurled knobs that clamp mask.
 - b. Slide mask holder out.
 - c. Carefully place on a lint free wipe with vacuum groove facing up.
 - d. The mask-holder should be attached to the mask aligner by a thin vacuum tube. If the mask-holder you want to use is not connected to the vacuum tube, disconnect the tube from the current mask-holder and connect the tube to the desired mask-holder now.
 - i. The mask-holders are stored in the orange box between the two aligners
 - ii. Always store the mask-holders on a wipe with the vacuum groove facing up to avoid scratches.
 - e. Verify mask vacuum button not activated.
 - f. Place mask on holder so that the side with the pattern is facing up (away from the mask-holder), making sure that vacuum groove is completely covered.
 - g. Engage vacuum mask button.
 - i. If you hear hissing, the vacuum groove isn't covered.
 - ii. Disengage the vacuum mask button and reposition the mask.
 - h. Verify mask held in place.
 - i. Invert mask holder and slide into stage.
 - j. Clamp mask-holder by tightening the knurled knobs (finger tight and no more).
 - k. Turn on the microscope light and focus on your mask.
6. Select Proper chuck
 - a. Wafer should cover all vacuum holes. If it doesn't, use another chuck. If appropriate chuck is not available, see a photolithography qualifier for options.
 - b. Pull transport slide out and place appropriate chuck in slide, making sure that the chuck is inserted properly.
 - c. Extra wafer chucks are stored in the orange box between the two aligners.
 - d. The wafer chucks must be stored face-up on a soft, lint-free cloth when not in use.
7. Load Wafer
 - a. Pull the transport slide out from the right side of the stage if it is not already out.
 - b. Place wafer on the properly loaded wafer chuck, photoresist up using Teflon tweezers.
 - i. The substrate must cover all of the vacuum holes on the chuck.
 - c. Verify the separation lever is back if it is not already there.
 - d. Verify the contact lever is forward if it is not already there.
 - e. Gently slide chuck into alignment stage.
 - i. If the wafer transport slide does not move, verify that the aligner is not in contact.
 - ii. If it still won't move, do not force it. Contact one of the photolithography qualifiers.
8. Bring the wafer into contact.
 - a. **Don't** change z while in contact or in separation. Only change it when the contact knob is rotated completely towards you.
 - i. The z knob has been set so that it will read zero with a 20 mil thick piece of gallium arsenide exerting 250 μ m of pressure on a 60 mil thick mask.

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- ii. One full revolution of the knob corresponds to 150 μ m of thickness.
 - b. Rotate the Z knob counterclockwise about one-half rotation if you do not know the correct setting for your substrate. If you have used a substrate and mask that are the same thicknesses as the ones you are using now, set the Z knob to the setting that you used when exposing that substrate.
 - i. **WARNING:** The step above is extremely important. If the Z setting is too high, the substrate may be forced through the mask when the substrate is moved into the contact position. This will probably break the mask, the substrate, and it will damage the mask aligner.
 - c. Slowly turn the contact lever back (away from you) while looking into the microscope.
 - i. This will lift the wafer into position. Note that you will not be able to pull the transfer slide out when the contact lever is turned back.
 - ii. When the contact lever has been rotated completely, the contact light will illuminate
 - d. Do not adjust z-axis when in contact. Bring fully out of contact.
 - e. If you did not know the correct Z setting for your substrate when you loaded it into the aligner, you should have lowered it one-half turn before loading your substrate. Now, you will probably need to increase the setting to bring the substrate into contact with the mask. Follow the procedure below carefully to avoid damage to the mask, substrate, and mask aligner.
 - i. Make sure that the separation lever is back all the way.
 - ii. Make sure that the contact lever is forward all the way.
 - iii. Rotate the Z knob clockwise approximately $\frac{1}{4}$ turn.
 - (1) Bring the substrate into contact and see if you still need to bring your sample up more.
 - (2) Bring the aligner out of contact and repeat above procedure.
 - iv. If you raise the substrate too far, you may break the mask so be careful.
 - f. You can use the microscope to check the distance between the substrate and the mask.
 - i. While in contact, focus the microscope on the mask. Then focus it on the substrate and note the distance the microscope moved. This is the distance between the substrate and the mask.
 - g. Once the substrate is in contact with the mask, you may want to note the current Z knob reading. Next time you expose a substrate of this thickness, you can just set the Z knob to this number. When reading the Z knob, be certain to note the number displayed in the hole in the knob as well as the number on the outer ring of the knob.
9. Pull separation lever towards you.
- a. The contact light goes out, and the separation light comes on.
 - b. The substrate should not be able to move if it is in proper contact with the mask.
10. Align using X, Y and theta.
- a. Use low magnification objective (5x) for initial alignment, focusing on both sample and mask.
 - b. Do not over-adjust the X, Y or theta.
 - i. Adjustments for X and Y are 5mm on coarse and 0.05mm fine.

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- ii. Theta range 30°.
 - c. When adjusting magnification, adjust using turret. Do not turn turret by objectives.
 - d. The microscope manipulator is equipped with pneumatic brakes which can be unlocked by pressing the buttons on the manipulator handle; the top button enables Y motion, the bottom enables X motion, and both pressed together allow motion in all directions. The motion is intuitive as you look into the microscope—as you move the manipulator to the right, the microscope moves to the left, but the image moves to the right.
 - e. The easiest way to get a sample in alignment is:
 - i. Align x and y in the center of the sample.
 - ii. Move to one of the edges of the sample and adjust the rotation using theta until the desired feature is aligned.
 - iii. Move to the center of the sample and re-adjust X and Y.
 - iv. Repeat the above process until entire sample is aligned.
11. Push separation lever away.
- a. The separation light will go out and the contact light will come on.
12. Check exposure time and adjust as needed.
- a. Exposure times of over 5 minutes are not allowed.
13. Expose the wafer.
- a. Press the appropriate CI button on the lamp power supply. CI1=365nm, CI2=405nm. Remember that both wavelengths are exposed on the wafer, CI1 and CI2 just tells you which wavelength you are monitoring.
 - b. Stay clear of the microscope and press EXPOSE on the mask aligner control panel.
 - c. The microscope will lift and move towards you and the substrate will be exposed for the time selected. **DO NOT LOOK INTO THE UV LIGHT**. The mask aligner is exposing the substrate to ultra-violet light, which is damaging to your eyes.
 - d. During the exposure, the lamp power supply will display the power the bulb uses to maintain a constant exposure intensity ($13.5\text{mw}/\text{cm}^2$ for 405nm or $6\text{mw}/\text{cm}^2$ for 365nm).
 - e. Note the exposure power and record it in the logbook.
14. Rotate contact knob fully towards you.
15. Return the X, Y and theta controls to approximately the center of their travel.
16. Slide chuck out and remove wafer.
- a. Double check that the separation lever is back and the contact lever has been rotated towards you. This will take the substrate out of contact with the mask and lower the substrate chuck back onto the transfer slide.
 - b. Pull the transfer slide out from the right side of the stage.
 - c. Remove the substrate from the chuck.
17. Unload mask reversing the load procedure.
- a. Loosen the knobs on the side of the mask-holder slot.
 - b. Carefully slide the mask-holder out of its slot and place it mask side up on the table.
 - c. Release the VACUUM MASK button on the front panel of the mask aligner. This will release the vacuum that is holding the mask on the mask-holder.

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- d. Remove the mask from the mask-holder.
18. Turn down the microscope intensity.
19. Verify that all requested data has been entered in the logbooks.
20. Immediately clean up any mess you make. A messy work area can create unrepeatable processes due to contamination. Before leaving the aligner, make sure the work area is cleaner than when you arrived.
21. Do not leave your mask in the aligner while developing your sample. Other people may have need of the aligners.

The following processes have yielded straight wall profiles and good critical dimension control. They might not be exactly what you need for your process, but give a good indication of a starting point. If you obtain different results or have additional photoresists you would like to add to this list, contact the photolithography qualifier and the data will be included in the next issue of this document.

All processes have included a clean, dehydration bake, adhesion promoter spin, photoresist spin, soft bake, exposure using CI2 (405nm), post-bake and flood exposure (for image reversal) and development. Deviations from these steps should give different results.

Resist	Spin Speed & Time	Softbake Time & Temp	Expose Time	Post Bake	Flood Expose	Develop	Develop Time
5214 positive tone	5000 30 sec	90°C 90 sec	5.5 sec	none	none	1:4 400K	60 seconds
5214 image reverse	5000 30 sec	90°C 90 sec	3.5 sec	112°C 60 sec	60 sec	1:5 400K	45 seconds
4330	5000 30 sec	90°C 90 sec	11 sec	none	none	1:4 400K	60 seconds
4620	5000 30 sec	90°C 120 sec	17 sec	none	none	1:4 400K	60 seconds
Futurrex NRD-1300	4000 30 sec	120°C 90 sec	12 sec	None	None	DE-2355	150 seconds

6.1.2 Emergency Shutdown

In the event of a laboratory evacuation the aligner can be left on. No emergency shutdown procedure is needed.

Occasionally, we have unplanned power outages or nitrogen outages. When an outage lasts for more than one second, the UV lamp cannot maintain its “on” state. The power supply reacts by turning off the lamp. The lamp must then be restarted. The power supply will be dark or display *rdy* if this happens. This means that power or nitrogen was interrupted, the lamp was turned off and the power supply is indicating that it is

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ready to ignite the lamp again. DO NOT START THE LAMP! **Contact a photolithography qualifier immediately for assistance.**

If one of the mercury lamps breaks, turn off the aligner and the power supply. Evacuate everyone from the clean room for at least 30 minutes. Contact the photolithography qualifier and the cleanroom technician for approval to re-enter the clean room. This is one instance where it is imperative that you contact a photolithography qualifier, even if they are at home.

6.2 Developer bench

The developer bench is used to develop photoresist. Most photoresist developers are bases. Do not use the developer bench as a base bench. There is a base bench in the cleanroom for you to use.

6.2.1 Normal Operation

There is one developer bench for everyone in the cleanroom to use. Because of this, everyone needs to keep the bench clean. There are a few rules to follow when using the developer bench. Most of the rules are common sense, but it is a good idea to be reminded of them occasionally.

- Clean up the bench when you finish using it.
- Do not pour photoresist or solvents down the drain in this bench. It is a violation of city law to do so, and anyone caught violating this rule will be severely reprimanded.
- The rinse baths are connected to a timer so the DI water system is not depleted by continuous flow of DI water. The left rinse bath is considered the “dirty” bath and the right bath is the “clean” bath. Always rinse your sample in the dirty bath, and then move to the clean bath. Do not place samples directly in the clean bath.
- It is suggested that you develop a sample in fresh developer and rinse in flowing DI water. Developer that sits out for as little as an hour begins to lose its effectiveness and can cause photolithography failures. If you feel you must leave your developer sitting, put it in a properly labeled, covered container for no more than 1 week. Containers that are over 1 month old or are improperly labeled may be disposed of. A properly labeled container should contain the following information: Users name, date, time, chemical(s) and concentrations. Open containers are not allowed.
- Used developer may be poured down the drain (even though this contradicts the video). After pouring the developer down the drain, run the sump flush for at least one minute and rinse the sink out
- Replace all hand sprayers, both water and nitrogen, back properly. If you do not know the proper placement for these sprayers, you need to be retrained. Contact the cleanroom technician for cleanroom retraining.
- If you empty a bottle of developer, rinse the bottle three (3) times with DI water and dispose of the capped, empty bottle in the trash. Do not put empty developer bottles under the developer bench.
- If you open the last bottle of developer, contact the cleanroom technician and place a note on the white board in the gowning room. The cleanroom technician will request more be ordered.

6.2.2 Emergency Shutdown

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The developer bench should be left on in the event of a cleanroom emergency. Do not attempt to rinse or dry your samples in the event of an emergency; leave the cleanroom.

6.3 Hot plates

The hot plates are used for many purposes in CHTM. Because of their multiple uses, you must become familiar with how to set the temperature on them. Allow several minutes for the temperature to stabilize. If there is a note on the hot plate saying not to change the temperature, don't. Do not put anything flammable on the hot plates, no matter what their temperature!

6.3.1 Normal Operation

1. Turn on the hot plate using the switch on the right front if it isn't already on.
2. The hot plate will display the current temperature. To set the temperature, press **"set"**, **"1"**, **temperature desired** and **"ent"** in this order. While the hot plate is warming up or cooling down, it will alternately display the current temperature and the temperature set point. Once the temperature of the hot plate is over 60°C, a small red light on the front of the hot plate will turn on to indicate that the plate is warm.
3. The hot plate has a built in timer. To set the timer, press **"set"**, **"5"**, time desired in minutes:seconds and **"ent"** in this order. As soon as **"ent"** is pressed, the hot plate will begin to count down to zero. Upon reaching zero, the plate will beep 3 times, indicating that it has reached the end of its time. To return the display to temperature, press **"1"**.
4. Clean silicon wafer on hot plate when finished soft-baking photoresist. Remove the silicon wafer from the hot plate, allow it to cool, then clean with acetone and rinse with isopropanol. Dry and return the wafer to the hot plate. If you are unable to clean the wafer, contact one of the photolithography qualifiers and they will tell you how to clean the wafer.

6.3.2 Emergency Shutdown

In the event of an emergency or cleanroom evacuation, the hotplates can be left on.

6.4 Microscope

The optical microscopes are used to inspect samples before and after process steps. The microscopes are not equipped with yellow light filters, so it is not recommended that you leave unexposed photoresist under the light for very long if you plan on placing the sample back in developer. One of the microscopes is equipped with an automatic turret for changing the objectives. It is imperative that the objectives are not moved by hand. Always use the switches to change the magnification.

6.4.1 Normal Operation

Wipe off the sample stage of the microscopes with a soft cloth and isopropanol before use. Rotate the microscope objective to the lowest magnification. Place your sample on the stage. Use a clean wipe if you do not wish your sample to be placed directly on the stage, do not use microscope slides! Move your sample under the objective. Turn up the intensity of the bulb. Look at your sample, increasing the magnification as needed. When finished, rotate the microscope objective to the lowest magnification. Turn down the intensity of the bulb. Remove your sample and verify that the sample

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stage is clean. Take care not to let the microscope objective lens touch the sample; it could scratch both the lens and sample. Do not force the focus adjustment or the stage movements.

6.4.2 Emergency Shutdown

The microscopes can be left on in the event of a cleanroom emergency or evacuation.

6.5 Ovens

The ovens are used for many purposes in CHTM. Because of their multiple uses, you must become familiar with how to set the temperature on them. Allow several minutes for the temperature to stabilize. If there is a note on the oven saying not to change the temperature, don't.

6.5.1 Normal Operation

1. Turn on the oven using the dial ring on the left side. Use the power setting that is appropriate for the temperature desired.
2. Adjust the temperature using the dial ring on the right side. Note that the temperature setting is only approximate and you will need to use the thermometer for accurate temperature measurements.
3. Allow at least 60 minutes for oven stabilization. If changing temperature, allow at least 30 minutes for stabilization.
4. Occasionally, the oven will overshoot to the point it trips its internal circuit breaker. To reset, press the red button on the left side of the oven.

6.5.2 Emergency Shutdown

In the event of an emergency or cleanroom evacuation, the ovens can be left on.

6.6 Solvent benches

There are 3 solvent benches in the photolithography bay. Each bench is designated for specific materials. There are specific rules for each bench, but there are some rules that are common to all three benches and are detailed in this section. Most of these rules are common sense and courtesy, but it doesn't hurt to remind you of them.

- Clean up your messes.
- Work as far back in the bench as possible and avoid disrupting the airflow into the bench.
- Avoid covering the perforated surface of the bench or the exhaust vents with wipes as this disrupts the airflow of the bench.
- Refill solvent wash bottles if there is less than 50% of the solvent remaining.
- Large quantities of solvent should be poured into the solvent carboys. Smaller amounts of solvents can be allowed to evaporate, but under no circumstances should you leave the container unattended.
- For safety purposes, do not use a hot plate in these benches without first contacting a cleanroom technician.
- If you open the last bottle of a solvent, contact a cleanroom technician and leave a note on the white board in the gowning area, and they will request more be ordered.
- Wipes used in solvent processes may dry at the back of the bench, but dispose of them when they are dry. Do not allow wipes to accumulate at the back of the bench,

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and do not leave the photolithography bay if you are allowing wipes to dry at the bench.

- If you empty a solvent bottle, the correct procedure is to uncap the bottle and allow it to dry. When it is dry, cap the bottle and dispose of it in the trash.
- If you a sample needs to sit in solvent for an extended amount of time, it should be in a properly labeled container. A properly labeled container should list the following information: Users name, date, time, chemical(s) and concentrations. Open containers are not allowed.
- Replace all hand sprayers, both water and nitrogen, back properly. If you do not know the proper placement for these sprayers, you need to be retrained. Contact the cleanroom technician for cleanroom retraining.
- Do not move the solvent wash bottles from bench to bench. There should be sufficient bottles for each bench. If the bottles are empty, refill them.

6.6.1 Normal operation of the solvent benches

The first bench, and the cleanest solvent bench is the “No Metal” bench. Samples in this bench must not have any metal on them. Solvent wash bottles must not have any metal on them either. If you use this bench, make sure that it is very clean when you are finished. We will not tolerate photoresist residue on this bench. Also, do not pour solvents down the drain in this bench. It is a violation of city law and anyone caught doing that will be severely reprimanded.

The second bench is the “No Lift-off” bench. Samples in this bench may have metal on them, but you are not allowed to do lift off in this bench. This bench is the “medium cleanliness” solvent bench.

The third bench is the “Lift-off” bench. This is the only bench where you are allowed to do liftoff processes. There is an acetone airbrush on this bench to assist in lift-off processes. If the acetone bottle supplying the airbrush is empty, you are responsible for putting a new one in place. When doing lift-off or photoresist removal, always place a towel under your sample and thoroughly wipe the bench off when done to remove traces of photoresist and/or metal.

6.6.2 Emergency Shutdown

The solvent benches can be left on in the event of an emergency or cleanroom evacuation.

6.7 Spinners

The spinners are used to spin a uniform coating of photoresist on your wafers. Extreme care must be taken while spinning photoresist because it is easy to contaminate the photoresist. Samples are being spun at such a high speed that they may fly off and injure someone if the spinner is not properly used.

6.7.1 Normal Operation

1. Verify that there is sufficient photoresist for your process. If there is not enough photoresist at the spinners, extra small bottles of photoresist are stored in the refrigerator in the photolithography bay.

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- a. If there are no small bottles of photoresist, contact one of the photolithography qualifiers. Do not pour photoresist for yourself!
- b. If you do remove a bottle of resist from the refrigerator, let it come up to room temperature before using it. Cold photoresist will cause photolithography failures.
 - i. It will take approximately 1-2 hours for the photoresist to come to room temperature. Do not open a bottle of cold photoresist.
 - ii. If you are removing a bottle of photoresist from the refrigerator, leave a note on the bottle indicating the time when it can be used.
2. Turn on the spinner using the switch on the front panel if the spinner is not already on.
3. For easier cleanup, cut a hole in the center of a Tex-wipe and line the spinner bowl with the Tex-wipe.
4. Select a spinner chuck.
 - a. The spinner chuck vacuum surface should be smaller than the size of your sample to avoid clogging the vacuum lines with photoresist. Change the spinner chuck if needed.
 - b. If you are found clogging up the spinners, you will be responsible for disassembling them and cleaning them.
 - c. Be sure that the spinner chuck is on the spindle properly. If you do not know how the spinner chuck should be put on, you need to be retrained. See a photolithography qualifier immediately.
5. Place your substrate on the spinner chuck.
 - a. The substrate should be centered on the chuck.
 - b. Substrates that are not centered may fly off the chuck, injuring someone.
6. Test the spinner by pressing the front of the foot pedal. The substrate should spin.
 - a. If the spinner buzzes and does not spin, the vacuum interlock has not been satisfied.
 - i. Take your sample off, and verify that the bottom of the sample does not have any photoresist or particles on it.
 - ii. If the vacuum interlock still is not satisfied, remove the spinner chuck and make sure it and the spindle are clean.
 - (1) Clean the spinner chuck and spindle with methanol to avoid degradation of the o-rings.
 - (2) Put the spinner chuck back on properly and then try again.
 - b. If the vacuum interlock is still not satisfied, contact someone on the photolithography team. **Do not** keep trying to start the spinner. The spinner will need to be cleaned. You will be asked to help in the cleaning process.
7. Adjust the time and spin speed to the desired settings. Some examples of spin speeds have been listed in this document.
8. Place a small amount of adhesion promoter on the sample if desired and start the spinner.
9. Allow the spinner to run it's complete cycle, and then using a clean disposable pipette, place a **small** amount of photoresist on the surface of the sample.
 - a. It is not necessary to cover the sample to the point where photoresist runs off the sample—you will be more likely to clog the spinner vacuum lines that way.

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- b. Start the spinner immediately after applying the photoresist as the solvents in photoresist begin evaporating immediately.
 - c. Do not return unused photoresist to the bottle, as this causes contamination.
 - d. The pipettes are single use only, so do not re-use pipettes to avoid contamination.
 - i. If you **know** that a bottle of photoresist is contaminated, pour out the photoresist into the waste container, let the bottle dry at the back of the spinner bench and let one of the photolithography qualifiers or the cleanroom technician know about it.
 - ii. If you **suspect** contamination, repeat the process on a bare silicon piece using a standard process. If it still fails, contact a photolithography qualifier for further assistance.
 - e. Excess photoresist must be disposed of in the waste bottle. Do not put pipettes containing photoresist in the trash.
10. Press the front foot pedal to spin the substrate. Allow the spinner to run through its entire cycle. If you need to stop the spinner for any reason, press the back foot pedal.
11. When finished with the spinner, clean up the spinner bowl with acetone and isopropanol.
- a. Make sure to clean under the bowl and the bottom of the bowl as well.
 - b. If the bowl was lined with a Tex-wipe, place the Tex-wipe in the photoresist trash and remove any photoresist residue.
 - c. A good time to clean the spinner is while your samples are soft baking.
12. Record your spin information in the logbook. If it is found that you are not recording your spin information, you will be required to re-qualify in the photolithography bay.

6.7.2 Emergency Shutdown

In case of an emergency in the cleanroom, the spinners can be left on.

7.0 ADDITIONAL RESOURCES

There are manuals available for most of the equipment in the photolithography bay. Contact the cleanroom technician or photolithography qualifier to check out these manuals.

The aligners undergo preventive maintenance approximately 3 times a year. If you would like to be notified when this maintenance occurs, contact the photolithography qualifier. The maintenance engineers are valuable information resources.

The Karl Suss MJB3 aligners are common in research laboratories. Many universities have their operating procedures available online, and you might be able to gather some tips from their operating procedures. Any modifications to procedures should be discussed with the photolithography qualifier.