Center for Integrated Nano-Technologies

Operating Procedure for
Integration Lab Chemical Benches & Spinners
(IL Chem Bench & Spinner OP)

1. PURPOSE

This document will provide information for the safe and proper use of the CINT Chemical Benches located in the Integration Lab, building 518. Any questions beyond the scope of this document should be directed to the equipment owner(s) or ES&H coordinator.

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.

CINT- Center for Integrated Nano-Technologies
ES&H – Environmental Safety and Health
Haz Mat- Hazardous Material
MSDS- Material Safety Data Sheet
PPE- Personal Protective Equipment
PR- Photoresist
QA- Quality Assurance
S&S- Safeguards and Security
SNL- Sandia National Laboratories
SOP/OP- Standard Operating Procedure/Operating Procedure
TGMS- Toxic Gas Monitoring System
UV- 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 Coordinator – Provides ES&H, S&S, and QA for CINT activities.
IL Staff – Integration Lab Staff who provide Equipment support and Safety training for users. IL Staff are typically Key Operators for multiple tools.

4. RESPONSIBILITES

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 Lithograpy tools or processes, users must complete all IL Unescorted Access (ILUA) Corporate and Operations training.

5.1 Corporate training

Integration Lab Authorized 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:

- *Chemical Bench & Spinner OP* (this document)- for chemical and spinner operations
- The applicable *Aligner OP*(s)- for aligner operations

5.3 Tool Specific training

Prior to using Chemical Benches the Key Operator must instruct the potential Authorized User on the safe and proper operation of the tool to minimize the hazard risk to the user and the tool. After successful completion of the tool specific training, the Key Operator will provide a recommendation to the Integration Laboratory Manager for the potential Authorized User to have tool access. Once authorized, the user will be able to use the tool independently.

6. APPROVAL, NOTIFICATIONS, 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 an Integration Lab badge indicating that they have been trained to use the Integration Lab and specified equipment. A user must have their badge above the waist outside their cleanroom suit at all times when in the Integration Lab. NOTE: The Integration Lab badge is not a substitute for the users' DOE issued badge. The DOE badge must also be worn at all times while in the CINT facility.

7. SAFETY PRECAUTIONS AND LIMITATIONS

General safety precautions are addressed in the *IL General OP*, which is a prerequisite for all other IL training. The major hazards for operations covered in the *Chemical Bench & Spinner OP* are listed below.

7.1 Chemical Burns

There are several chemical benches located within the lithography lab. A user must always be cautious when working with chemicals and follow the procedures outlined in the SOP. Serious and permanent damage can result from contact with the chemicals. It is also important to be aware of people in the vicinity to prevent another user from being injured by accidental exposure. As with all chemical handling it is a user's responsibility to be familiar with the appropriate MSDS, and to ensure that the smallest amounts necessary are used. Never keep a large container of ANY chemical out on the bench. Pour the minimum amount needed and keep containers closed in a safe uncluttered area. In case of exposure every room located in the Integration Lab has an emergency eye wash as well as a shower. However it is crucial to be informed on the chemicals you are using, as different types may require different treatment after exposure.

Note: When handling HF it is imperative that all precautions be exercised. Hydrofluoric acid is corrosive and a contact poison. Symptoms of exposure to hydrofluoric acid may not be immediately evident but can be fatal. It should be handled with extreme care, beyond that accorded to other mineral acids. Due to its low dissociation constant, HF penetrates tissues quickly. A face shield and full PPE should be worn at ALL TIMES while handling HF. PPE as well as face shields can be obtained in the chemical storage closet (Room 1516). PPE can be reused and hung up in the chase behind the lithography room (Room 1522).

7.2 Fume Inhalation

As with all chemical handling it is necessary to remain aware of the dangers of fume inhalation. The benches all have integrated fume hoods, but it is a user's responsibility to ensure the fume hoods are running at an acceptable rate. Even with proper fume ventilation a user should never allow open chemical containers to accumulate in the hoods. An excess of chemical fumes can be harmful to a person physically and can also result in an explosion.

7.3 Burn Hazards

The lithography lab houses several hot plates. Both direct and indirect contact with the hot plates can be extremely dangerous. It is important to be aware of which hotplates are in use whenever working in the area. Also note that cool down time varies after a user has shut off hot plate. Always be cautious even if hot plates are off and never store any kind of equipment or chemicals in hot plate vicinity.

7.4 UV Burn Hazard

Prolonged exposure to diffused reflection from the Mask Aligner 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 no equipment gives direct UV exposure.

7.5 Ozone Poisoning

Some equipment contains/uses ozone gas. Never use said equipment if proper ventilation of the gas is not available. If you suspect a leak or build up of gas clear the area immediately and contact the ES&H coordinator.

8. CHEMICAL BENCH USER GUIDE

There are 3 categories of Chemical Benches in the Integration Lab.

- Solvent Bench- for use with solvents. Waste is captured in carboys under the bench. Benches are plumbed with N2. Water is not used in solvent benches.
- Acid Bench- a wet bench segregated for acids and oxidizer-acid mixes. Benches are plumbed with DI water and N2, and typically have DI rinse baths. Waste is routed to the onsite Acid Neutralization plant.
- Base Bench- a wet bench segregated for bases (alkalines) and oxidizer-base mixes. Benches are plumbed with DI water and N2, and typically have DI rinse baths. Waste is routed to the onsite Acid Neutralization plant.

8.1 Solvent Bench Set-Up

The solvent bench is designed to process a variety of materials using common solvents. Although single sample processing is the intent, the system is designed to accommodate a variety of processing requirements. Ventilation air flow enters the front of the solvent bench horizontally across the work surface into a common plenum. This air flow stream captures and safely redirects potentially hazardous vapors away from the equipment operator. The chemical storage area is also ventilated to aid in the removal of refugee fumes from the compartment.

In the workspace area, two filtered nitrogen guns with independent pressure control regulators are provided for dusting or drying of samples. Centrally located on the work space is a solvent waste collection point that channels the waste to a five gallon stainless steel carboy. A Headway PWM-32-PS-R790 spin coater is integrated into the work surface to allow small sample processing up to 10,000 rpm. Controlled heating of samples up to 220°C in the workspace is made possible through integration of a Teledyne explosion proof stirrer hot plate. This hot plate is designed to safely operate in the solvent bench.

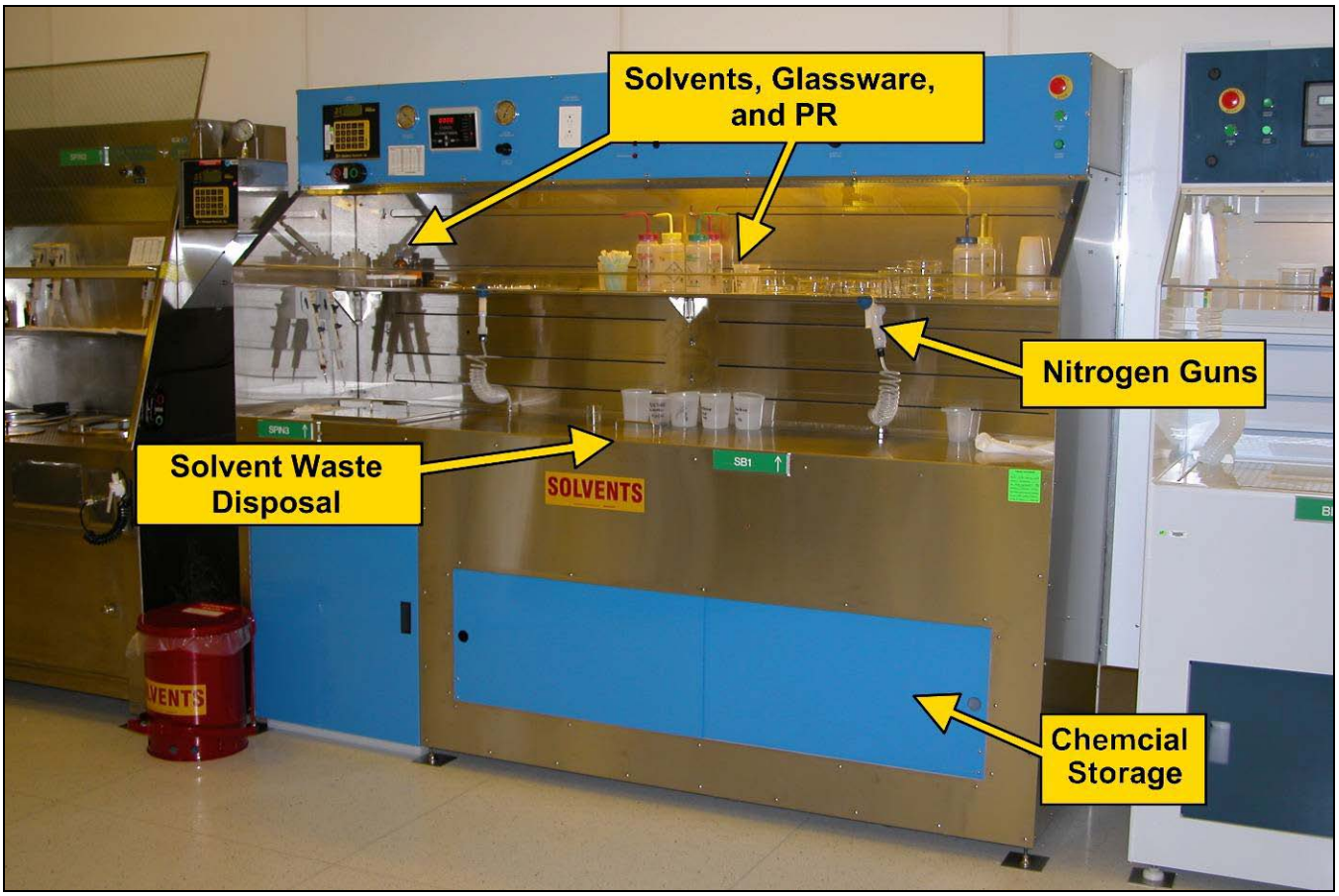

Figure 8-3 Solvent Bench located in lithography room.

8.2 Solvent Bench Controls and Alarms

Door Open – Reminds users to close chemical storage doors if they are left open for longer than ten minutes. Alarm cannot be silenced until the doors are closed.

Exhaust Flow – Nominally the face velocity of air flowing across the front opening of the bench is approximately 100 fpm (Feet Per Minute). This ensures that there is adequate air flow across the work surface area. This engineering control protects the user from accidental exposure to potentially toxic chemical vapors. If the air flow drops below 50-80 fpm for ten seconds, the alarm will sound and the exhaust LED will turn on. If the air flow rises above 80 fpm, the alarm will automatically clear. The alarm can be silenced by pressing the alarm silence/reset button.

Solvent Carboy Level – When the five gallon solvent waste carboy reaches 90% of capacity, the alarm will sound and the solvent carboy level LED will turn on. This alarm can be silenced by pressing the alarm silence/reset button however the alarm will sound again every thirty minutes until the problem is corrected. The interlock override function will disable this alarm.

Spinner Carboy Level – When the five gallon spinner waste carboy reaches 90% of capacity, the alarm will sound and the spinner carboy level LED will turn on. This alarm can be silenced by pressing the alarm silence/reset button however the alarm will sound again every thirty minutes until the problem is corrected. The interlock override function will disable this alarm.

Error Trapping – Embedded into the PLC ladder logic is an error trap that allows the processor to be interrogated for troubleshooting phantom alarms. When an alarm occurs, the memory bit associated with

the fault conditions is automatically latched. Please refer to the memory map and PLC ladder logic for details as to the location of these bits. The error trap can be cleared by simply cycling the interlock override function (Active-Off-Active).

Energy Saver Function – Every evening at 11:59 pm the bench enters into a sleep mode where power consumption is reduced to 10 watts. The bench is awakened when a user turns on the lights. In full operation, the bench will consume slightly more than 2 kilowatts of electricity. All automatic functions may be overridden by installing a jumper between the appropriate terminal blocks inside the electrical box. Please refer to the system schematics and PLC ladder logic for details.

8.3 Acid/Base Bench Set-up

All acid and base benches are set up similarly (Figure 8-1). The semiautomatic wet sink is designed to process and DI water rinse a variety of materials using common acidic or basic chemistries. Although single sample processing is the intent, the system is designed to accommodate a variety of processing requirements which can include batch processing. Ventilation air flow enters the front of the wet bench and moves horizontally across the work surface into a common plenum. This air flow stream captures and

Figure 8-1 Base bench located in lithography room.

safely redirects potentially hazardous vapors away from the equipment operator. The chemical storage area is also ventilated to aid in the removal of refugee fumes from the compartment.
In the workspace area, two filtered nitrogen guns with independent pressure control regulators are provided for dusting or drying of samples. A DI water gun with a zero static flow recirculation loop is also provided to allow dispense of DI water without adversely affecting water quality.

Cascade Rinse Bath Theory of Operation

There are three independent semi-automatic cascade rinse tanks integrated into the surface of the countertop. Each rinse tank consists of two isolated PVDF baths that are jointly fed with a single 18.2 Mohm-cm DI water stream. The right side bath contains a resistivity probe that allows the user to monitor bath contaminant levels during the first rinse step. When the bath resistivity rises above 13

Mohm-cm the sample can be moved to the left side bath for final rinse. The final rinse bath's ultimate resistivity is typically greater than 17-17.5 Mohm-cm. When the pre-rinsed sample is placed into the final rinse bath any remaining water soluble contaminants are quickly swept away from the substrate's surface. Due to the aggressive nature of DI water, the second rinse bath quickly absorbs low level ionic contaminants from the substrate surface further enhancing rinse quality. This two-stage rinsing methodology is very efficient and is well suited for small sample R&D processing. In many cases a sample can be effectively rinsed from start to finish in less than 6-8 minutes.

If a sample's composition can be adversely affected by the corrosive nature of DI water, carbon dioxide can be injected into the tank rinse water stream. When the function is activated approximately 100 ppm (or less) of carbon dioxide is injected and mixed with the incoming 18.2 Mohm-cm DI water stream. This effectively creates a high purity carbonated water for substrate rinsing operations. To ensure adequate mixing, the carbon dioxide and DI water travel through a 6-element static mixer before entering the first and second rinse baths. During carbon dioxide injection, the resistivity probe will indicate a relatively high bath water conductivity (low resisitivity) level. Typically this type of rinse is a timed operation with 3-5 minutes of sample submersion in the right bath followed by 3-5 minutes of sample submersion in the left bath. Substrates exposed to this carbonated chemistry will be effectively rinsed and passivated to protect corrosion sensitive surfaces.

To reduce the possibility of bacteria growth and contamination between users, the rinse baths are periodically cycled. After four hours of inactivity, the cascade rinse baths will automatically cycle. This automatic cycle introduces DI water into the three rinse baths for a period of ten minutes. After a period of one hour the rinse baths are automatically drained. This cycle will continue to repeat every four hours.

Cascade Rinse Bath Operation

STEP 1- Press the associated tank fill button (Figure 8-2), the green fill LED will turn on. DI water is introduced into the selected cascade rinse bath for a period of ten seconds with both drain valves open. This short sequence purges residual contaminants from the bottom of the tank and valve area into the sink's drain.

STEP 2- After the ten second purge, the drain valves will close and the drain LED will turn on. Both rinse baths will begin to fill at a combined rate of approximately two gallons per minute. Within one minute, the tanks will fill to overflow into the facility waste water drain. This overflow condition will continue for a period of ten minutes. Rinsing the sample can begin as soon as the tanks begin to overflow.

STEP 3- Submerge the sample into the right rinse bath until the bath resistivity is greater than ~13 Mohm-cm on the associated tank resistivity screen (Figure 8-2). When the desired resistivity level is achieved, remove the sample from the right rinse bath and place it into the left or final rinse bath. After approximately three minutes the sample can be removed from the final rinse bath and dried. The rinse tank will remain filled for a period of one hour following rinse initiation. After one hour has elapsed the drain valves will open and the drain LED will turn off. It will take approximately 1-2 minutes for the tank to completely drain. If desired the rinse time can be extended by ten minutes. Press the tank fill button once if the tank fill LED is not on and press the fill button twice if the green tank fill LED is on. The rinsing operation can be halted at any time by pressing the tank button. The tanks can be drained at any time by pressing the tank drain button.

Figure 8-2 Upper acid/base bench controls and LED's.

Rinse Tank 1 Carbonated DI Water Operation

STEP 1- Push the tank CO_2 activate button, the yellow button's LED will turn on several seconds after the switch is activated. No further action is required to initiate the carbon dioxide/DI water rinse operation. Initially the tank fill green LED will turn on and DI water will be introduced to tank for a period of ten seconds. During this short duration, both drain valves will remain open to effectively flush contaminants from the bottom of the tank to drain. After ten seconds the drain valves will close and the drain LED will turn on. Three seconds into the flushing sequence, carbon dioxide will be introduced into the tank DI water stream. The yellow CO_2 LED will turn on when the carbon dioxide is introduced. Tank will begin to fill at a rate of approximately two gallons per minute with carbonated DI water. Within one minute, the baths will fill to overflow and will continue to overflow for a period of twelve minutes. If desired, the carbon dioxide flow rate can be adjusted using the flow control valve located on the bottom of the flow meter (Figure 8-2).

STEP 2- Submerge the sample into the right rinse bath for a period of 3-5 minutes. After the desired elapsed time, remove the sample from the right rinse bath and place it into the left or final rinse bath. After a period of approximately three minutes the sample can be removed from the final rinse bath and dried. To purge residual gas from the make-up DI water stream, carbon dioxide flow will shut off approximately two minutes before DI water flow stops. The rinse baths will remain filled for a period of one hour following the tank fill request. After one hour the tank drain valves will open and the drain LED will turn off. It will take approximately 1-2 minutes for tank to completely drain. If desired the rinse time can be extended by ten minutes. Press the yellow tank CO_2 inject button once if the yellow LED is not lit, or twice if the yellow LED is lit. This will increase the rinse time by ten minutes. The rinsing operation can be halted at any time by pressing the green tank fill button. Carbon dioxide injection can begin at any time during a normal DI rinse operation by pressing the yellow tank CO_2 inject button.

Sample Recovery from a Rinse Bath

If DI water is flowing into the rinse tank, press tank fill button to stop water flow to the cascade rinse tank. After the tank rinse LED turns off, press the tank drain button to drain the tank. After 1-2 minutes, the tank will completely drain and the sample can be recovered.

8.4 Acid/Base Bench Controls and Alarms

Door Open – Reminds users to close chemical storage doors if they are left open for longer than ten minutes. Alarm cannot be silenced until the doors are closed.

Exhaust Flow – Nominally the face velocity of air flowing across the front opening of the bench is approximately 100 fpm (Feet Per Minute). This ensures that there is adequate air flow across the work surface area. This engineering control protects the user from accidental exposure to potentially toxic chemical vapors. If the air flow drops below 50-80 fpm for ten seconds, the alarm will sound and the exhaust LED will turn on. This signals that a potentially hazardous condition may exist at the workstation. If the air flow rises above 80 fpm, the alarm will automatically clear. The alarm can be silenced by pressing the alarm silence/reset button.

Low DI Water Pressure – If facility DI water pressure drops below 15-30 psi for five seconds, the low DI water pressure alarm activates. All rinse operations are halted however the baths remain filled with DI water for a period of one hour following alarm activation. A DI water loop branching off of the main DI water distribution system runs through the bench. Loss of DI water pressure to the bench could result in contaminants from the rinse tanks to enter the DI water system. When the alarm activates, the DI water valves automatically close isolating the rinse tanks from the DI water distribution system. Rinsing operations will not commence until the problem is corrected and the fault reset. To silence the alarm, press the alarm/reset button once. To clear the fault condition press the alarm/reset button a second time.

Leak Detect – If a liquid spill is sensed in the chemical storage area, within five seconds the leak detect LED turns on and the system alarms. Because the nature of the spill is unknown, DI water flow to the rinse baths stop. The rinse baths remain filled with DI water for a period of one hour following alarm activation. Rinsing operations will not commence until the problem is corrected and the fault reset. To silence the alarm, pressure the alarm/reset button. To clear the fault condition press the alarm/reset button a second time.

Error Trapping – Embedded into the PLC ladder logic is an error trap that allows the processor to be interrogated for troubleshooting phantom alarms. When an alarm occurs, the memory bit associated with the fault conditions is automatically latched. Please refer to the memory map and PLC ladder logic for details as to the location of these bits. The error trap can be cleared by simply cycling the interlock override function (Active-off-Active).

If alarm goes off the associated problem will light up. Pressing ALARM SILENCE/RESET once will silence the alarm. Even through the alarm horn is silenced, the fault condition may remain latched preventing certain automatic functions. Pressing this button a second time will clear the fault condition. If the fault condition remains, the alarm will sound and the silence/reset cycle repeats. Check the problem area and press ALARM SILENCE/RESET again to reset system. In the event of a problem or leak please contact Key Operator and/or equipment owner immediately to resolve problem. In the event of an emergency the red EMERGENCY STOP button can be pressed at any time to cease all activity.

9. LITHOGRAPHY OPERATIONS

Every lithography process will be different with respect to the desired results. However below is a general guide for lithography lab use.

9.1 Solvent Bench Operations

The user's substrate may need to be cleaned on the solvent bench with appropriate solvents (acetone/methanol/isopropanol). Following solvent cleaning, the sample can be rinsed with DI water **in the adjacent base bench**. Solvents are located either on the shelf above the solvent bench workspace, or in the storage area below the bench (Figure 3). Be sure that all solvent waste ends up in the solvent waste container. Do **not** pour water into the solvent bench waste container. All waste disposal reservoirs are labeled with the associated hazardous waste it's intended for. The Solvent bench has a unique group of system alarms to protect users and the environment from chemical hazards. These alarms include low exhaust flow, solvent waste carboy level high, spinner waste carboy level high and storage door open. In the event of a low exhaust alarm, the user should place cover all open chemical containers before stepping away from the bench. Other than the door alarm, all system alarms should be reported to Integration Lab personnel. The storage door alarm only serves as a reminder to users that the a storage door needs to be closed. In the event of an emergency at the solvent bench, the red EMO switch should be activated to remove system power. A user should become familiar with a bench before using.

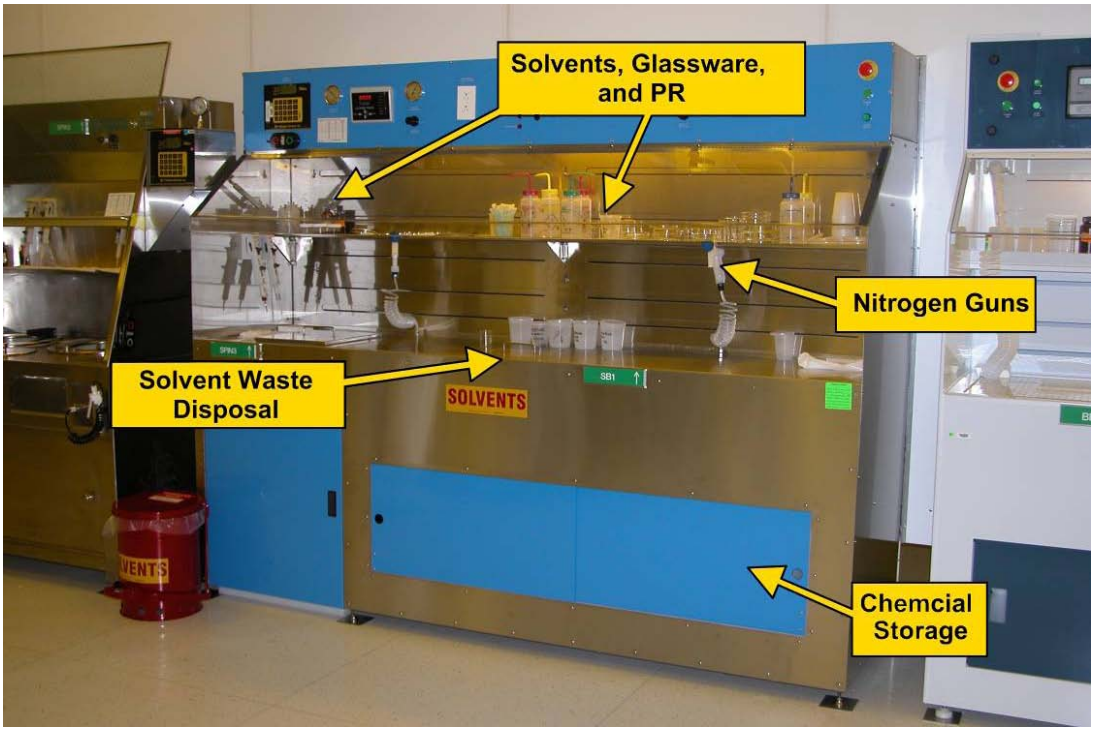

Figure 3 Solvent Bench

9.1 Substrate Preparation

The user's substrate may need to be cleaned on the solvent bench with appropriate solvents (acetone/methanol/isopropanol). Following solvent cleaning, the sample can be rinsed with DI water in the adjacent base bench. Do not add water to the solvent waste stream.

It is common to dehydrate the substrate to promote photoresist adhesion or to prepare the substrate surface for application of hexamethyldisalizane (HMDS). HMDS aids in enhancing the chemical bond between the photoresist and silicon. After solvent and subsequent DI rinse a user may take the substrate to one of the hot plates (Figure 4).

Figure 4 Hot Plate bench

For Hot Plate use:

Set desired baking temperature by pressing the up or down arrows. The red temperature represents the current temp while the green is the desired. It may take between 10-20 minutes for plate to obtain correct temperature depending on the initial conditions. The maximum operating temperature for HP1 is 400°C and HP2-5 is 300°C. If operating above 200°C, adjust the set point to 100°C when complete.

Set bake time on timer located on top of the hot plate.

Load substrate on top of the hot plate's Si barrier wafer.

If vacuum and/or nitrogen is desired turn on while simultaneously starting timer. For HP1 there are VACUUM/NITROGEN toggle switches on the front of the system. HP2-5 only have vacuum capability, and are engaged by rotating black knobs located behind the plate 90 degrees.

9.2 Resist Coat

The lithography lab has three spinners. Each spinner is associated with a specific type of PR/Polymer. Be sure and use the appropriate spinner for the type of process being run.

SB1-TBA

SB2-TBA

SB3-TBA (polymer)

If HMDS prime (adhesion promoter) is desirable it can be located in the upper hood of the spinner benches, however it's not necessary for all processes.

Coating of the wafer with resist by spinning requires a uniform coat. Repeating pippets for particular PR/Polymers are located next to the associated spinners. Most syringes will already contain PR (labeled on syringe). If the date on the syringe is older than a week it is a good idea to dispose of contents in waste disposal and refill. Small 500-1000 ml ambler glass containers of PR can be found in Rm1516 refrigerator. Users are to fill syringes from the small containers to prevent contamination of the larger 4L

container. Integration Lab personnel are the only individuals allowed to pour resist from the larger containers. It is mandatory that the chemical be transported in an approved carrier to the solvent bench. These can be found next to the refrigerator in Rm1516.

The resist *must* be poured in an exhausted hood. Containers should be returned immediately to refrigeration after syringes are filled. ALWAYS REMEMBER TO LABEL SYRINGE WITH NEW REFILL DATE.

NOTE: Remember to include a 30 minute wait before extracting the resist from the 2-oz container into the syringe. This will allow the viscosity of the fluid to drop making the extraction process much easier as well as not subjecting the resist to undo mechanical stress.

All three of the spinners operate off of a PWM32 Control Unit (Figure 5). A recipe is defined as a sequence of steps that is programmed into the control unit. A recipe is identified by a number 0-9 on the control panel. Within any recipe a step is identified by a number 1-9. A user can program and keep a commonly used recipe on a specific number, however it is a good idea to double check that recipe is correct before beginning use. The system can be in one of 5 states. Each of these states is clearly displayed by word or action on the LCD display: READY, RUNNING, REVIEWING, PROGRAMMING, and ABORT.

Figure 5 Spinner Control Unit

PROGRAMING A RECIPE
Before programming a new recipe onto a spinner please double check that needed recipe is not already present on a preset. If the desired program is already set on the control unit skip to SPINNING PROCEDURE.
Set Programs for Spinners:

Program 1- 1300RPM, 30 sec
Program 2- 2400RPM, 30 sec
Program 3- 3000RPM, 30 sec
Program 4- 4000RPM, 30 sec
Program 5- 5000RPM, 30 sec

Program 6- 6000RPM, 30 sec
Program 7- 7000RPM, 30 sec
Program 8- 500RPM, 10 sec - 2500RPM, 30 sec - 600RPM, 30 sec
Program 9- 500RPM, 30 sec - 4000RPM, 30 sec
Program 0- OPEN for All Users to Create Specialized Programs

STEP 1) CLEAR PROGRAM NUMBER. Decide the recipe number you wish to use store the program in. Please note that Number 0 is open for users. If possible try to use open numbers out of courtesy for other users. Press the function key labeled RECIPE (in the READY state only, see above on how to restore READY state) and then the desired number on the key pad. If this recipe already has a program you may modify the existing steps and add new steps as desired to get the program you want. If you want to reduce the number of steps or prefer to start with a clean slate, the entire recipe must be erased by pressing the function keys labeled RECIPE then CLEAR and then the recipe number (again in READY state only). The recipe number entered will then show to be a recipe with zero (0) steps. It can now be reprogrammed.

STEP 2) PROGRAMMING FIRST STEP. Press the function key labeled STEP, and then pressing 1 on the key pad (If altering an intermittent step in a preexisting process press the first step needing to be altered).

a) Press the function key labeled SPEED/RAMP. Enter the desired speed and verify it as displayed in the LCD Press the ON or ENTER key to accept the number keyed in for the speed or ramp. Note the SPEED/RAMP key is a toggle between the speed and ramp (acceleration) of spin.

b) Again press the SPEED/RAMP key. Enter the acceleration/deceleration for this particular step, and verify it in the LCD. Press ON or ENTER to accept the entry.

NOTE: When entering numbers, the OFF or CLEAR key will act as a backspace key to allow correcting an entry prior to pressing the ON or ENTER key. Once ON or ENTER has been pressed it will be necessary to back out of step and reprogram.

c) Press the function key labeled FUNCTIONS to see different outputs that may be controlled during this step.

d) Most commonly the step terminator will be time, as set on the step timer. If a process calls for an event to take more than 999.9 seconds, then it will be necessary to series two or more sequential steps with the same process conditions to obtain the longer time desired. To set terminator time enter the time (in seconds) and press ENTER or ON.

STEP 4) PROGRAMMING SUBSEQUENT STEPS. To program additional steps press STEP then desired step number. Proceed with setting the desired speed, ramp, functions and step terminator as in programming step 1. Proceed until all desired steps are programmed. When all steps have been programmed, terminate the recipe by pressing the function key labeled STEP, and then the number zero (0) on the key pad. This will return you to the READY state.

STEP 5) ENDING SPIN. An additional step of programming can be used at the end of the cycle to bring the spinner to zero RPM at a more satisfactory deceleration rate. Add additional step to the recipe and make the speed and timer equal to zero, and set the ramp to a satisfactory rate. The "stable speed" feature prevents the step timer from starting until the speed set in the step has been reached at the set ramp rate. Therefore the spinner will decelerate at the desired rate until it reaches zero and then instantly terminate.

A recipe may be reviewed or modified by pressing STEP and the step number to be reviewed or modified (when in the READY state).

SPINNING OPERATION

Please read through all steps before beginning a spin. Upon arrival the control unit may not be in READY mode. If system is in ABORT state press START. If the unit is in REVIEWING or PROGRAMMING press STEP and then 0. Once LCD displays READY the unit is prepared for recipe programming. 11

1. The currently selected recipe number is shown in the upper left-hand corner of the LCD display. Recipes are selected by pressing the function key labeled RECIPE, and then pressing the number of the recipe desired. The selected recipe number will be written to the LCD.

2. Below the recipe number in the LCD display, the active step (when a program is running) and number of the last step of the recipe is displayed, example: 2-6 means the process is in the second step of a 6-step

process. If the process has not yet been started, then only the number of the last (highest) step of the recipe is shown, preceded by a dash.
3. Every step has a timer that can be set by the process programmer. If this timer times out, it will terminate the step. It can be set anywhere between zero and 999.9 seconds. Other events can be programmed to terminate the step, but the event must occur before the time set on the timer. Setting the timer to zero can temporarily skip a step. The time remaining in the currently running step is always displayed in the field of the LCD marked TIME.
4. Once programmed, a single step cannot be erased or eliminated. The step can be skipped by setting its timer to zero, or all steps of a recipe can be simultaneously erased by pressing the function keys RECIPE then CLEAR then (Recipe #). The highest step in the recipe becomes zero (0). Once all steps of a recipe have been erased, the recipe can be reprogrammed as desired.
5. Vacuum to the chuck/substrate can be managed automatically by the system, or can be forced to stay on by the operator. The vacuum ON/AUTO function key is a toggle. A two character field at the left of the LCD displays the current status: 0N = Manually, AU = Automatic.
6. A rotation sensor on the motor forces the vacuum to be turned on if the motor is spinning, overriding all other control of the vacuum. This insures that the vacuum will continue holding the substrate to the chuck until the spinner comes to a complete stop.
7. If a recipe is running in a step, that step can be immediately terminated by the operator by pressing the function key labeled OFF or CLEAR. It is also possible on any or all steps to program the START switch as a step terminator.
WARNING: The operator MUST be aware of what could happen if a step is skipped without its normal programmed termination. This will be unique to the user-programmed activities. The user should be prepared to quickly ABORT the entire sequence, if something unexpected occurs when a step is skipped prematurely.
8. The START/ABORT switch is a dual, center-balanced rocker footswitch. The side with the green circle is the start switch; the side with the red circle is the abort.
9. If a process is aborted, the START switch becomes the RESET switch, to return to READY.
10. While a recipe is running, the speed of the spinner may be increased or decreased manually by pressing the STEP TERMINATE (increases speed), or SYSTEM PARAMETERS (decreases speed). This manual speed change is temporary, it does not change the speed set in the program.
11. The step timer does not start timing, until the speed for that step is reached. Thus the total time for the step will be the sum of the acceleration (or deceleration) plus the time setting of the timer. A slow ramp setting can significantly effect the total step time.
12. The SYSTEM PARAMETERS key: Pressing this key permits you to disable the audible alarm, or adjust its time period. Also, motor speed recalibration can be accomplished, if an external accurate tachometer is available to measure the motor rpm. If the calibrate mode is entered but re-calibration cannot be accomplished, be sure to reenter the numbers displayed to avoid destroying the existing calibration. Other information about the programming of the specific controller is also displayed under system parameters.

Some recipes may require a soft bake (pre-exposure bake) to drive off some of the solvent in the resist. Follow the above instructions for hot plate at desired time/temperature.

9.3 Exposure

After soft bake the substrate may be exposed with either of the mask aligners located in the lithography lab (ALIGN1 and ALIGN2). The relevant Aligner OP and Tool Specific Training are required prior to aligner operations.

9.3 Post Bake

If recipe designates a post exposure bake (makes resist more resistant to etchants other than developer) the substrate can be taken directly over to hot plates (see above for hot plate usage).

9.4 Develop

Development is the selective removal of resist after exposure (exposed resist if resist is positive, unexposed resist if resist is negative). To develop the substrate may be taken over to the base bench. Developer can be found in the chemical storage area of the bench. Please be sure and transfer developer from large containers to small containers. Never use developer directly out of large container. Glassware is located to the right of the base bench and should be used for development. There is a color coding scheme applied to certain rinse baskets and dishware. This allows the user to segregate metal ion free (TMAH – Yellow) developing operations from metal ion containing developers (KOH - Black). Metal ion contamination in metal ion free developers can adversely affect developing operations to a point where a photoresist pattern may not completely resolve.

After the pattern has completely resolved in the developer solution, the sample must be placed in a cascade DI rinse bath. The first rinse which is the left of the tank divider allows the user to monitor bath resistivity to determine when the sample has been sufficiently rinsed. Transition to the final rinse which is to the right of the divider usually occurs when the first bath resistivity rises above 13 Mohm-cm. The final rinse bath quality is typically better than the 17.5 Mohm-cm. Following removal from the second rinsing operation, the sample is dried with filtered nitrogen. Developer can be disposed of in <100 ml quantities at the base bench's waste collection point. A hard bake may be necessary after pattern develop to enhance a photoresist's ability to withstand chemical or thermal attack during aggressive processing operations.

Please note that disposable PE containers can also be provided with lids for those who wish to segregate incompatible chemistries from other users. These containers must be appropriately marked with chemical name and user information. The containers can be kept in the bench area for as long as room permits, then they are thrown away.

9.5 Microscopy

There is an optical microscope located in the lithography lab for use between steps and after development. The microscope is set up to provide sample analysis in one of four modes that include bright field, dark field, fluorescent and DIC. When sample analysis is complete, the lamp intensity must be reduced to a minimum level to slow down degredation of the microscope's optics. For detailed outline of microscope and/or software use please refer to the associated OP located in the Microscopy FUG.

10. HAZARDOUS WASTE

All hazardous waste must be properly labeled and stored. Container must:

- be chemically compatible with waste,
- have an approved hazardous waste sticker listing the name of the waste generator, their organization number, and the type of waste generated,
- be stored in a secondary container,
- be stored in an approved Hazardous Waste storage site

In most cases, IL Staff provide hazardous waste containers. If you are unsure of the proper disposal method,

- Transfer your waste to a separate, chemically compatible container
- Label it as described above
- Contact IL Staff for guidance

Always refer to MSDS for proper chemical handling and segregate incompatible waste by placing it in separate containers. Refer to Chapter 19A of the ES&H Manual for further requirements and guidance. If hazardous waste containers are full, notify IL Staff.

10.1 IL Solvent Waste Protocol

Liquid Solvent Waste Disposal – Approved liquid solvent wastes are poured into the solvent sink located in the solvent bench (figure 3). The waste is captured in a carboy below the bench (figure 8-4). Do not add water to the solvent waste stream.
Solid Solvent Waste Disposal – Solid waste is disposed of in the countertop storage areas on far right and left sides of the spinner bench. Solid waste includes solvent-contaminated wipes, gloves, and labware/containers contaminated with photoresist.

10.2 IL Acid and Base Waste Protocol

Liquid Acid and Base Waste Disposal – The compatible bench sump flush is activated, then approved liquid acid, base and oxidizer wastes are poured into the bench funnel. Acid and Base bench drains are routed to the onsite Acid Neutralization plant.

Minute amounts of solvent (as from water rinsing a sample cleaned with solvent) are permitted. Do not pour solvents into
Solid Acid and Base Waste Disposal – Solid waste is disposed of in the hazardous waste containers, labeled Acid Hazardous Waste and Base Hazardous Waste. Solid waste includes acid/base contaminated wipes and gloves. If wipes are saturated with acid or base, rinse with DI water in a chemically compatible sink before adding to waste container.

Figure 8-4 Hazardous waste containers in solvent bench

11. SIGNATURE OF COMPLETION

By my signature below, I affirm that I:

• Have read and understand this operating procedure (OP) entitled ***Integration Lab Chemical Benches Operating Procedure***

• Have read and understand the PHS/HA for this laboratory and signed signature page

• Will take the required training before working in the Integration Lab or using any specific equipment

Name (Printed)	Signature	Org	Date