



Lab Manual

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Chapter 1.2

Microlab Chemical Hygiene Plan

Safety Rules & Procedures

Cal/OSHA (Title 8 CCR Sec.5191) requires that all laboratories have a written Chemical Hygiene Plan as a fundamental chemical safety plan for the laboratory. Chemical Hygiene Plans are required to include laboratory specific hazards and safety information. A hierarchy of administrative controls, engineering controls, and safety equipment form the basis of the chemical hygiene plan.

The designated Safety Officer of the Microlab is Bob Hamilton (bob at eecs.berkeley.edu). The Microlab Chemical Hygiene Plan (CHP) is a component of the Department of Electrical Engineering and Computer Sciences Injury and Illness Prevention Program (IIPP). Since 1992, the Berkeley campus has required all departments maintain an IIPP.

The following Microlab safety rules must be read, understood, and practiced at all times. Think about your actions and how they will affect other lab members, as well as yourself. Use common sense and consideration when working in the Microlab. Be aware of your own and everyone's safety. If you see a lab member practicing unsafe procedures, do not hesitate to walk up and remind fellow lab members of proper procedures. Safety violations and hazards should be reported via the computer, or if you prefer, using the anonymous suggestion box next to the first aid kit in the lab hallway. Safety is an ongoing effort with laboratory procedures and rules continuously evolving.

The rules and procedures outlined here are for the protection of you and your Microlab colleagues. Failure to follow safety rules can result in serious injury. Lab members found violating Microlab safety rules and procedures may be denied access to the Microlab. If you have any questions, feel free to ask a staff member or to email safety at silicon.eecs.berkeley.edu. There are no excuses for not following safety procedures.

Lab members found violating Microlab safety rules and procedures will be denied access to the Microlab.

I. GENERAL SAFETY INFORMATION

A. The Cardinal Rule – Never Work Alone

NEVER WORK ALONE. This rule is absolute and non-negotiable. To find out if there are lab members working in the Microlab, check the WAND:

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CATEGORIES(space)
* ALARM -> USE PULL-DOWN STATION!!!
c Chemicals and Materials
e Equipment
E Equipment Communication
g General Purpose
h Help
==>i Info. About Lab Members and Fees
l Lab Manual and Your Lab Notes
m Mail and Messages
p Process Logs
r Reservations
s Sign Out of Lab
S Safety, Trouble & Prevention
v Visitors

TASKS(space).....
. b Basic Lab Fees
. B Basic Equipment Fees
. c Your lab charges this month
. C Your charges for an item
. d Dial Intercom Codes
. f Finger file information (NEW)
. g Research groups
. p List members by advisor (professor)
. r List members by research group
. s Staff Hours
.==>w Who is in the lab
. W Who has been in the lab recently
. u Show all usage of a lab resource
.
.....
TASKS IN PROGRESS(%)
HELP
- Use "s" to SIGN OUT
- Enter character next to item
- SPACE moves between main menus
- Use ? (and !) for help info

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From a login terminal or a CAPE terminal within the lab you may simply type **labwho** or **lw** at the login prompt.

If no one is currently working in the Microlab, you must wait and log in with at least one other lab member. To facilitate the cardinal rule, the first lab member who logs on receives the following message:

"Warning: All other lab users are idle and may have gone home. It is against lab policy to be in the lab alone."

To prevent a lab member from being left in the Microlab alone, a lab member who logs out leaving only one lab member in the Microlab receives this message:

"Warning: You appear to be the last user in the lab. Please notify anybody else left in the lab that you are leaving. It is against lab policy to work alone."

If you are found working in the Microlab alone, access privileges will be suspended.

Once in the lab, use the buddy-system, locate a lab member and inform them where you will be working. Check up on each other regularly. If no one else is present, you must leave the lab until you can find another lab member. It is a good idea to plan ahead if you want to work in the evening or on a weekend. To facilitate following the cardinal rule check the on-line lab reservation program to find out when other members are planning to be in the lab. Although you cannot under any circumstances work alone inside the lab, you may, however, work alone in the lobby area.

B. Handling Emergencies After Hours

The Microlab Emergency Phone Numbers list is posted by EVERY lab telephone as well as at the front entrance. For major emergencies, fire or injuries call 911. Follow-up all emergency phone calls with a call to staff. The nature of the emergency will determine whether you will call 911 followed by a phone call to staff or simply a phone call to staff:

The following is a list of the phone numbers from the Emergency Response Plan; when placing calls to staff, call them in the order listed until you reach a live person.



Micro/NanoLab Phone Numbers



Emergency		People			Rooms	
Injury, Fire or Crime	Equipment or Facilities	Adrienne	406 Cory	14	145 Cory	2-7650
Serious Injury, Fire or Bomb 85 Campus Police Campus Building/Facilities Cory Building/Facilities Tang Center for minor injuries Hours: M - F 8:00 AM - 6:00 PM Sunday 9:00 AM - 5:00 PM	Call in order below until you contact a listed person live. Bob Hamilton 510-644-3329 Cell: 510-325-7557 Bill Flounders 510-845-4847 Cell: 510-301-1082 Phill Guillory 650-359-1335 Cell: 510-225-5674 Mike Linan 707-864-2605	Al	406 Cory	22		52
		Attila	520C-13 SDH	809-8627	AM1	33
		Ben	187 Cory	44	AN3	31
		Bill	520A SDH	809-8613	CMP Room	50
		Bob	406 Cory	16		
		Brian	413 Cory	43		
		Changrui	550 Cory	3-7542	Gas Room	17
		Danny	242-2 SDH	809-8634		
		David	520C-5 SDH	809-8619	GL3	45
		Evan	406 Cory	17	Jeol/EE143	3-8136
	406 Cory	21	Leo mscope	2-7650		
	406 Cory	18	(145 Cory)	52		
	242-3 SDH	809-8635				
	406 Cory	27	Lobby	36		
	406 Cory	20				
	406 Cory	15	Machine Shop	44		
	406 Cory	28		3-8400		
	406 Cory	23	Fax	2-4990		
	242-4 SDH	809-8636				
	406 Cory	24				
	406 Cory	25	Novellus	51		
	475 Cory	3-4297				
	520C-7 SDH	809-8621	Old Lab	32		
	520C-3 SDH	809-8617				
	187-406 Cory	53	Phill's Students	809-8635		
	556-2 SDH	809-8639				
	242-5 SDH	809-8637				
	406 Cory	30	Reception 406	10		
	406 Cory	29				
	520C-16 SDH	809-8630	Storeroom 421	35		
	406 Cory	12				
	556-1 SDH	809-8638	Tech Room	34		

RS - 12/10/03 - Micro-Nano Phone List

In case of fire, use the red fire alarm pull boxes. If someone is severely injured, call 911 to summon emergency medical help before you call staff. Tell them your location and the nature of the emergency. Follow all instructions of the emergency response operator.

For a facilities problem, such as a flood or a utility problem that does not represent a danger to the lab members but may result in damage to equipment, call the Microlab Staff. **Do not** call 911 for problems limited to facilities or equipment. **Always call 911 when a potentially life-threatening or severe injury exists (injury, fire, gas leak, suspected bomb, etc.).**

For security issues call the UC Police Department at 2-3333.

For non-Microlab building issues call the campus facilities hot-line at 642-1032 followed up with a call to Cory Hall's Building Manager, Scott McNally at 510-917-3511.

C. HAZMAT Alarm

Microlab has a Hazardous Material Alarm (HAZMAT) to evacuate the Microlab and shut off corrosive and toxic gases. **Lab members should activate the HAZMAT alarm if they suspect a corrosive or toxic gas leak.** Activate the HAZMAT alarm by pulling the lever on one of the blue alarm "pull boxes". Instructions are printed on the pull boxes. **HAZMAT IS A LOCAL ALARM ONLY – NOT A FIRE ALARM. ACTIVATING THE HAZMAT ALARM DOES NOT CALL 911.** Lab members must evacuate the Microlab when they hear the HAZMAT alarm. Lab members may remain in Cory Hall if no Fire Alarm has sounded. Lab members may re-enter the Microlab only after staff determine the nature of the emergency, correct the situation, and declare a safe condition.

The HAZMAT alarm is not connected to the Cory Hall FIRE ALARM system and does not signal emergency service or the police. **IN CASE OF FIRE, USE THE RED FIRE ALARM PULL BOXES.** If you activate a FIRE ALARM, follow up by activating the HAZMAT alarm – "If you pull red, then pull blue too".

Activating the HAZMAT alarm results in:

- 1) A loud chirping alarm sound and a flashing light.
- 2) Automatic shutoff of corrosive and toxic gases at their source within the gas cabinets.
- 3) A signal to an off-campus alarm monitoring company with instructions to call Microlab staff.

In addition to hand-activated pull stations, the HAZMAT alarm is automatically activated by the Microlab toxic gas monitoring system described in Section 13c.

D. Microlab Evacuation Procedures

1. When the building fire alarm sounds, you **MUST** evacuate Cory Hall. Always assume it is for real unless you hear a formal announcement over the Lab Page system that it is a test or false. Advise doubters to make that same assumption and evacuate the building. Follow the Cory Hall Evacuation Procedures found at

<http://www.eecs.berkeley.edu/department/emergency/coryemergency.html>

(also available at the Microlab website, under Safety and Emergency – Cory Hall Emergency Procedures. A printed copy of the Cory Hall Evacuation Plan can be found in the fire hose cabinet by the northwest stairwell. When the alarm sounds or evacuation announcement is made over the intercom, you **MUST** evacuate the Microlab. Secure your process, take any personal belongings, and leave the lab quickly but calmly. Take the stairs to the exit floor (Level 2) and exit Cory Hall onto Hearst Ave. Do not return to Cory Hall until the Fire Department gives the 'all clear'.

2. If an alarm sounds and the Microlab staff is not present, evacuate other lab members as you leave. Unless YOU have activated the fire alarm, you do not need to activate the HazMat alarm as you exit the lab. Flip the evacuation sign located on the door glass to it reads: **MICROLAB HAS BEEN EVACUATED DO NOT ENTER.**

3. Campus Warning Siren: in case of a campus-wide lockdown, remember three basic steps: 1) SHELTER, go or stay inside any building, 2) SHUT all doors and windows, and LISTEN, dialing 1-800-705-9998, www.emergency.berkeley.edu, or tune a radio to 90.7 FM. The campus warning siren is tested at noon on the first Wednesday of each month.

E. Safety Awareness

Please report safety problems you encounter, on the WAND using FAULTS. The equipment name is "safety". Safety problems may also be reported on the WAND in CATEGORIES → S Safety, Trouble, and Prevention; r → Report a safety problem. In addition, a Suggestion Box is installed near the first aid kit in the lab main hallway. Your safety related ideas and observations can be anonymously submitted here. Many safety improvements were initiated by labmember suggestions.

Be aware of your own and everyone's safety. If you see a lab member practicing unsafe procedures, do not hesitate to walk up and remind him/her of proper methodology. Safety violations should be reported on the computer, or if you prefer, using a suggestion card next to the first aid kit in the lab hallway.

F. Laboratory Protocols

1. Clothing

Sandals, open toe shoes, hi-heels and bare feet are prohibited in the Microlab. Shorts are only permitted when wearing the full coverall clean room suits.

2. Gowning

The Microlab is nominally a class-100 cleanroom environment, i.e. less than 100 particles of diameter 0.5um or greater per cubic foot of air. The Class100 definition is approximately equivalent to the new international standard known as ISO 5. Gowning is required to protect this cleanroom environment of the Microlab. Minimum attire required while working in the Microlab consists of a Tyvek cap to cover hair ("Bouffant Cap"), Tyvek coveralls, blue shoe covers, and a Tyvek boot cover. In addition, nitrile gloves must be worn at all times. These items are provided by the Microlab and available in the gowning area. Store these items in your plastic gowning box and replace as needed. The gowning policy for visitors is less stringent. A disposable blue hairnet, a frock or coveralls and blue shoe covers are used as well as nitrile gloves. The hairnet, shoe covers and gloves are one-time use items and should be discarded after visitor use. Frocks and coveralls should be reused if they are in good condition. Coat hooks are available in the lobby to store visitor frocks and coveralls.

3. Eyewear

You must wear safety glasses in the Microlab at all times. Only safety glasses approved by the American National Safety Institute (ANSI) and meeting the ANSI Z-87.1 standard are allowed. Prescription safety glasses are available through the University of California Optometry Department: <http://www.caleyecare.org/eyewear.html> and are rechargeable to University contracts. See your grant administrator for information. Under certain circumstances, such as the presence of laser or UV sources, further specialized eyewear may be required. Send e-mail to bob at eeecs.berkeley.edu if you anticipate such a need.

Wearing of contact lenses in the lab is discouraged due to the hazard of trapping chemicals in or under your lenses. Soft or hydrated contact lenses may contain up to 50% water by weight and can become irritating if they absorb chemical vapors. Be aware of these additional hazards if you choose to wear contact lenses in the lab.

4. General Laboratory Practices

When in a lab, walk don't run. Avoid 'backing up'; always look where you are going. Don't rush. Wash your hands after leaving the Microlab. Remember that the nitrile gloves must be worn at all times while in the Microlab and are intended to protect equipment and materials, not your hands. Avoid touching your face with your hands. Check your gloves frequently; put on fresh gloves if torn or contaminated.

5. Food and Beverages

Consuming food or beverages in any part of the Microlab, including the lobby, is forbidden. Use the kitchen/coffee room across the hallway for this purpose.

6. Cell Phones

Cell phone usage is permitted only in the Microlab hallway, gowning and lobby areas. Cell phones must not be used in laboratory equipment areas or when operating equipment, because cell phone signals have been shown to cause failures of the baseline interferometers used in lithography tools and the pattern generator. Lab members are reminded to be courteous to other members when using a cell phone in the hallway.

7. Music Players

Radios, music players and headphones are not allowed while operating equipment in the Microlab. These devices may only be used in the Microlab gowning, hallway, and lobby areas

8. Visitors

Visitors are allowed by permission only. All Microlab visitors must be associated with the research missions of the Microlab and its lab membership. Friends and family members do not qualify. To request permission for visitors e-mail: visitor at silicon.eecs.berkeley.edu. All visitors must be logged in at a CAPE terminal using the category VISITORS. All visitors must remain in the company of their host and are not permitted to use Microlab equipment. Photography is permitted.

9. Personal Hygiene

UCB EH&S and Microlab recommend that lab users wash their hands after leaving the Microlab, even if no known exposure has occurred. Remember that the nitrile gloves you must wear at all times while in the Microlab are intended to protect equipment and materials, not your hands.

G. First Aid

Injuries, such as minor burns and cuts can be treated with the first aid kit located in the main hallway inside the lab. Report all use of a first aid kit on the WAND under equipment / problems / safety. List the items used from the first aid kit in your report. The first aid kit can be removed from the wall if necessary. An additional first-aid kit is available in the office.

Injuries, which require treatment by a health care professional, must be documented. This includes filling out a Workman's' Compensation Report and an Occupational Accident, Injury or Illness Investigation Report. These forms are available in the Microlab Office and should be completed within 24 hours of medical treatment or on the Monday following a weekend.

Lab members familiar with first aid should come to the aid of colleagues. California has a Good Samaritan law protecting people who give first aid from legal liability.

II. CHEMICAL SAFETY

A. Chemical Information & Reference Materials

Microlab members primarily use "standard" chemicals. These are chemicals stocked by the Microlab. Chemicals stocked in the Microlab are for use in the Microlab and Microlab's satellite Cory Hall laboratories ONLY. Microlab standard chemicals are not for use in other departments or research facilities. You can view the list of standard chemicals on the WAND:

CATEGORIES(space)	TASKS(space).....
* ALARM -> USE PULL-DOWN STATION!!!	.==>c Chemicals available
=>c Chemicals and Materials	. C Checkout chemicals or materials
e Equipment	. d Dry chemicals available
E Equipment Communication	. m Materials available
g General Purpose	. M Microlab MSDS index (:q to quit)
h Help	. s Spill cleanup
i Info. About Lab Members and Fees	. S Material Safety Data Sheets Info
l Lab Manual and Your Lab Notes	.
m Mail and Messages	.
p Process Logs	.
r Reservations	.
s Sign Out of Lab	.
S Safety, Trouble & Prevention	.
v Visitors	.

Microlab members may also use “special” chemicals. A Special Chemical is any chemical that is not supplied and stocked by the Microlab. The term Special Chemicals also applies to source materials used for thin film deposition such as sputtering targets or the solid materials used for evaporations. Labmembers must review their use of Special Chemicals with Microlab staff and have all chemicals approved and labeled prior to bringing them into the Microlab. To bring a Special Chemical into the Microlab follow the procedure below:

- Obtain the Material Safety Data Sheet (MSDS). Most chemicals are delivered with an MSDS; if necessary, use a search engine to obtain the MSDS for your chemical.
- Request a Special Chemical review with Bill Flounders, Microlab Technology Manager (bill at eecs.berkeley.edu), bringing two copies of the MSDS. Order special chemicals through your own department or company. Ordering a minimal quantity reduces the disposal charge you will incur. You may arrange to have chemicals delivered directly to the Microlab. Discuss delivery arrangements with Susan Kellogg-Smith (kellogg at eecs.berkeley.edu) prior to ordering.
- Following approval of a Special Chemical, you will be provided with a green Approved Special Chemical label. Label your container before taking it into the Microlab. Please advise Microlab staff when you expend or remove the chemical, and do not intend to replace it.
- Even if your chemical has been previously approved, you must obtain a new Approved Special Chemical label for each new bottle you bring into the Microlab. This requirement is to insure that all chemicals brought into the lab are entered in the Microlab chemical inventory as required by the campus Environmental Health and Safety Department.
- An unlabeled chemical container is a general violation of Cal/OSHA regulations and may result in a heavy fine for each such container. Microlab staff will actively seek and dispose of any special chemical without the Approved Special Chemical label or any other unlabeled chemical containers in the Microlab.
- Chemicals are often passed from one member of a research group to another, as lab members leave and new members join. Members of any research group passing on chemicals have the responsibility to ensure that new labels are placed on the containers of any such chemicals, giving new owner and contact information. Microlab staff will dispose of any Approved Special Chemical if the listed owner has an extinct Microlab account.

Familiarize yourself with any chemicals you plan to use. Several references are available in the lobby workstation area. Use a search engine, such as www.google.com to secure Material Safety Data Sheets (MSDS) and for additional information on chemicals and materials prior to working with them. You may also consult with the UCB Office of Environmental Health and Safety regarding the properties and toxicology of your prospective chemicals. (EH&S 642-3188 or www.ehs.berkeley.edu. Be aware: The Microlab has special restrictions on the use of some chemicals such as elemental mercury and mercury compounds.

Note: Chemicals and Hazardous material cannot be shipped from the Microlab using common carriers or couriers such as FedEx, the US Postal Service or UPS. To send any package containing a chemical substance or hazardous materials contact the Microlab office during staff hours. We will direct you to a convenient campus shipping site trained to properly label and ship such material. This service, a service of UC Berkeley's Office of Environment, Health and Safety, is managed by campus-wide Hazardous Materials Shipping Program and complies with Federal and State regulations.

Pyrophoric Materials

Pyrophoric materials are water reactive liquids, solids or gases which ignite spontaneously on contact with air, moisture in the air, oxygen, or water. Many pyrophorics are also corrosive and toxic.

Lab members who wish to bring pyrophoric reagents into the lab must first review their process needs with Bill Flounders (**bill at eecs.berkeley.edu**) and receive permission to use these Special Chemicals. Prior to requesting an appointment, review the safety information available at

<http://www.ehs.berkeley.edu/healthsafety/pyrophoricsop.html>.

Be prepared to submit a Standard Operating Procedure (SOP) for your setup at the time of this review.

Some Nanolab systems, such as the picosun atomic layer deposition (ALD) system use pyrophoric precursors in their processes. Because these precursors are intrinsic to these machines, the processes are automated, and engineering safety systems are in place, lab members who use these tools need only to read the lab manual and become a qualified user.

B. Chemical Storage and Movement within the Microlab

Standard Chemicals for the Microlab are stocked in chemical safety cabinets located in the gowning area. If you need additional chemicals from this storage area:

- Check that there are no bottles of the chemical you need in your area before bringing in and opening new bottles.
- Chemical storage cabinet doors must be closed after removing items.
- Chemicals in glass bottles must be transported through the lab using safety carriers. Remember to return these safety carriers to the gowning area.
- Do not return opened standard chemicals to the gowning area storage cabinets.
- Notify the lab office, if there is no stock of the chemical you need in the gowning area.

There are also several approved chemical storage cabinets throughout the Microlab. Standard chemicals and Special chemicals with a green, Approved Special Chemical label may be stored in one of these approved chemical storage cabinets. Storing chemicals in lab member storage areas or drawers is not permitted.

Working-Chemical Storage

Lab members occasionally find it handy and economical to save chemical solutions for on-going use. Microlab requires lab members to store working solutions in securely sealed, screw-top containers. Plastic wrap or aluminum foil covers are not acceptable. All containers must be labeled with detailed contents, date, lab member's login name and contact information. Microlab staff will dispose of any improperly stored working solutions.

C. Working with Chemicals

Most chemical handling is done at a fume hood or a wet process station. Working with chemicals outside of a fumehood or wet process station is prohibited. Fume hoods and wet process stations are exhausted, with face velocities greater than 100 feet/minute. Make sure fume hoods equipped with moveable sashes have these sashes adjusted to their indicated position. This assures proper exhaust velocity. Specialized

equipment, such as the photoresist dispense and develop tools, have engineering controls to handle fumes and prevent exposure.

1. Personal Protective Equipment

You must wear chemically-rated gloves and a face shield when working with any chemicals. When working with large volumes of acids, etchants or corrosives, such as when filling a tank in a wet process station with etchant, or mixing an etchant, you **MUST** also wear a chemically resistant apron. Lab members can check out chemically-rated gloves from the Microlab office during staff hours. If an apron, or face shield is not available near your location, contact Microlab staff and the necessary items will be added to that area.

a. Gloves

Three types of gloves are commonly used in the Microlab.

Surgical Gloves (nitrile, blue colored) These gloves are available in bins located by the entrance to the lab main hallway. They must be worn at all times in the lab to protect lab surfaces from contamination of oils and salts on your hands. These gloves do **NOT** protect against chemical burns or solvents. Inspect and change your gloves frequently. Do not touch your face with them.

If you experience dermatitis or irritation from wearing gloves contact the Microlab office. Absorbent glove liners may help alleviate such issues.

Triple Polymer, Chemical Resistant (tan colored). These gloves are chemically rated and must be worn whenever you work with acids, etchants or corrosives. You can obtain them from the office. Carefully check them regularly for wear and replace them when needed. If you anticipate exposure of your gloved hands, you must regularly **leak-check** your acid resistant gloves. Do this by pressurizing them with a nitrogen gun and inspecting for leaks. Simply listening for leaks is usually sufficient. A more rigorous test is to pressurize a glove with nitrogen then immerse in water and check for bubbles.

A few pairs of chemical resistant gloves are stocked in the lobby for after hour's checkout. Do not use these gloves unless the office is closed.

Plastic Polyethylene Gloves (clear). These are available in many locations within the lab. Their purpose is to minimize contamination of process equipment and materials. Put on a fresh pair of these gloves over the surgical gloves each time you handle contamination-sensitive equipment or samples; for example, when loading an evaporation boat or e-beam crucible.

b. Respirators

A respirator is a device used to filter breathing air. Specific filters are available to absorb chemicals or capture particles. Fume hoods or other engineering controls are the preferred method of remediating inhalation hazards rather than respirators. If you think your operation requires a respirator, first discuss your plans with the Microlab Technology Manager (bill at eecs.berkeley.edu) or Microlab Safety Officer (bob at eecs.berkeley.edu). University policy requires all respirator use be reviewed and approved by the campus Occupational Health Services. **To procure a respirator, you must make an appointment with Occupational Health Service's Respiratory Fit Test Clinic at the Tang Center.** It will take about one week to receive your respirator, and there is a \$70 fee, which includes medical qualification, fitting, training, and supplies. Consult the following website:

<http://www.ehs.berkeley.edu/pubs/factsheets/48respiratoryprotect.html>

or call 2-6891 if you need more information

2. Dry Chemicals

Several scales for weighing dry chemicals are available in the lab. Chemicals are to be dispensed onto weighing paper or into weigh-boats, not directly onto the scale. When dispensing and weighing

chemicals **never pour a chemical back into its bottle**. This can contaminate the remaining chemical in the bottle. When dispensing dry chemicals, pour them from the container when possible. Scoop only when necessary and only with a clean spatula.

3. Solutions

When mixing acids with water, remember to **ADD ACID TO WATER** and **NOT WATER TO ACID!** An exception to this well-known rule is the wafer cleaning solution called "Piranha." This solution is a mixture of sulfuric acid and hydrogen peroxide. Piranha solution is made by first pouring the sulfuric acid and then adding the hydrogen peroxide. Be aware that reaction between hydrogen peroxide and sulfuric acid is exothermic, producing heat. The container you mix these chemicals in will become very hot. Chemical spills have been caused by lab members preparing a piranha solution, then grasping the beaker or container to move it and dropping the container when they discover it is too hot to hold. Use appropriate containers for your solutions. For instance, do not use glassware for HF as HF will dissolve glass. Only some plastics are chemically resistant to HF and other acids. Examples of compatible plastics are Teflon and polyethylene. Some plastics have limited use temperatures; never use a plastic container on a hotplate. All hotplates used in the Microlab must be digitally controlled. The Microlab supplies hotplates; if you wish to use your own, check with the office for a list of approved units. If you are uncertain if the container material you are using is compatible with your solution – review with lab staff.

WARNING: Two potentially serious accidents have occurred in the Microlab with lab members working with hot piranha solutions in beakers. These accidents were virtually identical. Fortunately, no serious injuries occurred but both accidents had the potential for serious injury. These accidents occurred when lab members used wafer holders made in a machine shop. In both cases the material was assumed to be Teflon[®], a fluoropolymer, which is one of the few plastics compatible with hot piranha. In both cases, the plastic was not an acid resistant fluoropolymer. Upon immersion of these plastic wafer holders into hot piranha solution, the plastic reacted violently splashing liquid onto the researcher. Injuries could have been severe because in both accidents **LAB MEMBERS FAILED TO WEAR THE REQUIRED PROTECTIVE SAFETY EQUIPMENT.**

Make sure you clearly label all chemical processes with the chemicals used, with your name and contact information, with date and time, and with your expected time-of-return. Always place fuming containers toward the back of the fume hoods where there is maximum exhaust. It is best to not leave chemical processes unattended.

If you encounter an unidentified spill at a sink check the pH. The pH test strips can be found in plastic dispensers located at several locations throughout the lab or checked out from the Microlab Office. Color charts with reading instructions are laminated and posted by these dispensers. The pH test strips are calibrated to read from 0-14 pH. If the tested solution is strongly acidic (pH < 4) or strongly basic (pH >10), use a sink deck hose to flush the solution into the sink. If it is near neutral or when you have finished flushing, use a Techni-cloth to wipe and dry the surface. Additional information can be found under the Section "Chemical Spills".

4. Chemical Disposal

When you are through with your process, clean up completely. Proper disposal procedures:

- ▶ **Acids** (including piranha), **acetone** and water miscible **alcohols** such as 2-propanol (isopropanol) and methanol may be drain-disposed using an aspirator to remove their contents from the container. An aspirator has a Teflon[®] tube through which it sucks a liquid from a container. All Microlab wet sinks and fume hoods have an aspirator. The Microlab maintains an approved waste neutralization system to neutralize its waste stream before discharge to the Campus drain system. Warning: **NEVER POUR ACID, ACETONE or ALCOHOL directly down a drain: Always use the aspirator. Never mix solvents with acids when aspirating – This is a potentially explosive combination!**
- ▶ **Non-water miscible solvents such as hexane or benzene, and all halogenated organic solvents** such as chlorobenzene or TCA (trichloroethane) and photoresist, must never be

aspirated or poured down a drain. These wastes must be poured into organic waste disposal bottles located at specific sinks: (sink4, and sink432c). Open the lid of the special funnel on the solvent disposal bottle before pouring solvents into it and be sure to close the lid afterward to prevent the escape of volatile organic vapors. **Never pour acid or base solution into a solvent waste bottle because an explosion may result.** Make sure chemical disposal bottles are not overfilled. When a chemical disposal bottle is approximately 75% full:

- 1) Get an empty hydrogen peroxide bottle from the blue recycle bin in room 432B. These have special vented lids to prevent accidental pressure buildup.
- 2) Change bottles, loosely capping the full bottle. **DO NOT TIGHTEN THE CAP.** This prevents accidental pressure buildup from breaking the bottle.
- 3) Use a safety carrier from the gowning area to transport the chemical disposal bottles to the yellow Chemical Disposal Cabinet located in 432b.
- 4) Label the bottle with the HAZMAT sticker (your login name and the specific contents of the bottle); fill out the Chemical Disposal Manifest sheet located on top of the yellow cabinet, then place the bottle inside the yellow Chemical Disposal Cabinet.

If you have been instructed to maintain a separate waste bottle for your approved Special Chemical or self-created solutions, follow the procedure above, using a separately labeled waste bottle.

- ▶ Chemicals for disposal placed in the Chemical Disposal Cabinet must be labeled with contents and the login name of the lab member placing the chemicals in the cabinet. Placing unlabeled chemicals for disposal in this cabinet is a violation of lab policy, which may result in suspension from the Microlab. You must fill out the Chemical Disposal Manifest sheet located on top of the disposal cabinet. The bottles are picked up by the UCB Environment, Health and Safety Department. Notify the Microlab office if the storage area is full.
- ▶ Bring empty chemical bottles, plastic or glass, to Room 432C in the old lab. Use a safety carrier if the bottle is glass. Bottles that have previously contained water-soluble solvents such as acetone, methanol, 2-propanol (IPA) ethanol, photoresist developers, and the Nova Clean lab cleaner should be rinsed thoroughly with water at the black ceramic utility sink and then deposited in one of the designated trash cans in the rear passageway of room 432. Bottles which contained acids should be rinsed only at sink432c as this sink has a certified fumehood. Empty bottles which have contained chemicals such as HMDS and chlorobenzene (primarily used at sink-4 in the yellow room Y1) should be left at the rear of sink4 to evaporate before disposing in these waste cans. If you are unsure which sink to use, use sink432c. Bottles which have contained photoresist should be taken to sink432c, rinsed out with a small amount of acetone (rather than water) then the waste poured into the photoresist + acetone waste bottle at that sink. Wear a face shield and chemical-resistant gloves when rinsing empty bottles. The purpose of these procedures is to assure that discarded bottles do not contain any product and to protect our custodial and waste management staff from exposure to chemicals.
- ▶ For disposal of non-drain disposable solvent bottles, place the empty uncapped bottle to the rear of a fume hood to allow the bottle to completely dry out, and then place the bottle into a trash can.
- ▶ Clean glass bottles go in the recycle can located directly outside the chem room door. Clean plastic bottles which have been emptied of buffered HF or peroxide, go in the recycle can located farther down along the same wall. Bottles, which have been emptied, of silicon etch mixed by lab staff should be rinsed but not discarded. Place properly rinsed bottles into the white chemical cabinet to the right of sink432c.

5. Chemical Exposure

- ▶ If you are exposed to chemicals, you must immediately remove all affected clothing. Flush the affected areas with water for 15 minutes, not less. Use the emergency shower and/or eyewashes as necessary. The location of the safety showers and eyewashes are clearly marked with signs and identified on a map that follows this safety section. Memorize the locations of the safety showers and eyewashes.
- ▶ Contact a staff member after you have flushed the exposed area with water. If exposure occurs in the evening or on a weekend, contact a staff member listed on the Emergency Response Plan

posted by the phones. The Emergency Response Plan is also available on the WAND, - S Safety, and Trouble & Prevention. All injuries occurring in the Microlab must be reported to the office within 24 hours or on the Monday following a weekend.

- ▶ Exposure of the eyes requires flushing with water for at least 15 minutes. As a precaution, all exposures to the eye will require a visit to an emergency room for a check up. Contact a staff member as soon as possible for assistance or call 911.
- ▶ If you are exposed to a chemical while working at a wet process station (especially if splashed in the eyes), utilize the DI water deck hose to flush your eyes instead of trying to make your way to an eyewash station. Hold your eyes open and flush continuously for 15 minutes. The DI deck hoses will be your fastest response for such an emergency when working at a wet process station or sink.
- ▶ HF burns are particularly hazardous. An insidious aspect of HF burns is that there may not be any discomfort until long after exposure. These burns are extremely serious and may result in tissue damage as fluoride ions diffuse through tissue. If you contact HF, flush the area well and be sure to work under and around your fingernails. Under fingernails and cuticles are the main area people receive burns, having washed off the HF without washing under their nails. If washed off within a few minutes of exposure, HF will do no harm. Remember, HF may not produce any burning sensation until after it has already done damage. You should have a physician examine all HF burns.

First aid for HF burns to skin:

- (1) Remove contaminated clothing.
- (2) Flush with cold water for 15 minutes. Pay particular attention to the area around your fingernails and cuticles.
- (3) Gently massage calcium gluconate ointment into skin.
There is a container of this material in the Microlab First Aid Kit in the main hallway, and by the sinks where HF is used.
- (4) Report any HF burns to the office during work hours or call Microlab Safety Officer Bob Hamilton at 644-3329.
- (5) Seek medical examination at Tang Center or Alta Bates. It is not necessary to call 911 for a follow up physician examination.

6. Chemical Spills

During Staff Hours:

- A) Lab members should contain the spill using spill pillows and spill blankets found in the wall-mounted Spill Cleanup Stations in the main hallway, the rear of room 432 (old lab) and in the room 456 Chemical Storeroom. The material used in these pillows and blankets is selected for large moisture retention and its ability to neutralize acids. There is also a portable spill cleanup kit available which can be taken to the location of a spill. This kit is a 5 gallon white pail located by the eyewash/safety shower in the main hallway, and contains the same pillows and blankets as the Spill Cleanup Stations, but also has cleanroom gowns, gloves, a portable respirator and plastic hazardous disposal cleanup bags.
- B) Immediately report the spill to the office.
- C) Used blankets and pads should be placed in a plastic hazardous waste bag and deposited in the pail. It is important chemical cleanup materials be disposed of properly and not in the trash containers.

When Staff Is Not Available:

- A) Contain the spill using spill blankets and pads found in the wall-mounted Spill Cleanup Stations in the main hallway near the drinking fountain, the rear of room 432 (old lab) and in the room 456 Chemical Storeroom. The portable spill cleanup kit, which can be taken to the location of a spill, is

in a 5 gallon white pail by the eyewash/safety shower in the main hallway. Instructions are on the WAND under "S" – Safety, Trouble and Prevention.

- B) If the spill is significant or presents a serious hazard, use the HAZMAT alarm to evacuate the Microlab and contact a staff member using the emergency contact list posted by a phone and at the front door. Use spill blankets and pads to contain the spill; however, do not expose yourself or attempt to clean up a spill that is a serious health hazard.
- C) Contact a staff member using the emergency contact list at the front door. In all cases be sure and wash up following any spill-cleanup event. File a written report using FAULTS, equipment name safety.

CATEGORIES(space)	TASKS(space).....
* ALARM -> USE PULL-DOWN STATION!!!	. c Computer related problems
c Chemicals and Materials	. e Emergency telephone numbers
e Equipment	. E Emergency Response Plan
E Equipment Communication	. f Emergency flood procedures
g General Purpose	. C Chemical Hygiene Plan
h Help	. l Laser Operating Procedures
i Info. About Lab Members and Fees	. m Microlab MSDS index (:q to quit)
l Lab Manual and Your Lab Notes	. M Material Safety Data Sheets Info
m Mail and Messages	. p Equipment problems and comments
p Process Logs	. r Report a safety problem
r Reservations	.==>s Spill cleanup
s Sign Out of Lab	. S Microlab Safety Rules & Procedures
==>S Safety, Trouble & Prevention	.
v Visitors	.█

Report all spills using the FAULTS program on the WAND under equipment problem - safety.

7. Toxic Metals & Metal Dust

Toxic metals and some common metals such as copper and nickel have health risks. When handling all metals, minimize the risk of ingestion and inhalation. Use damp towels, the house vacuum cleaner or a portable HEPA vacuum to clean up dust and debris. Portable OSHA-rated HEPA vacuum cleaners are available in 157, 188 and 432 Cory Hall. Avoid using N2 blow off guns.

General Procedures for Handling Unreactive Hazardous Materials

- ▶ Minimize quantities.
- ▶ Clear your work area before starting.
- ▶ Protect bench tops using disposable covering.
- ▶ Change gloves each time you change work venue. For example, if the phone rings, take off your gloves before answering it. Do not re-use gloves, even if they look clean.
- ▶ Confine the material as you work. Clean up stray material before it can disperse: **DO NOT WAIT** till the job is done.
- ▶ Avoid chemical etching of parts with toxic materials when possible. An etch solution used with a toxic material must be treated as toxic and disposed of accordingly.
- ▶ Mechanical cleaning should be done at low velocity, especially if the work must be done dry. Keep a HEPA vacuum cleaner at the ready and work in a fume hood with at least 200 linear feet per minute face velocity.
- ▶ Whenever possible, use water or other non-toxic liquid to help confine dust.

Working with Gallium Arsenide (GaAs)

III-V compound semiconductor researchers should review the Material Safety Data Sheet (MSDS) for Gallium Arsenide prior to working with this material. Gallium Arsenide is ranked as a possible carcinogen if it is heated in air above 285°C. Volatile arsenic oxides form at this temperature in air. In addition, Gallium Arsenide is a hazard when ground, cut, or polished.

Grinding or wet lapping must be done in a fume hood in 432c. These operations must be done wet and residues must be rinsed in sink432c. No dry grinding or lapping of GaAs is allowed without hazard assessment by Microlab Safety Officer Bob Hamilton or the campus office of Environment Health & Safety.

Waste substrates should be disposed of in the Heavy Metal Waste container located inside the SURPLUS CHEMICAL CABINET in sink432b.

III. SHARPS & OTHER DANGEROUS OBJECTS

A. Broken Glassware

Broken glassware should be disposed of by depositing in the yellow pails designated for broken glass disposal. These pails are located in the front of the old lab (432), in CY2 and TC service areas. Contact a staff member if you need help disposing of broken glass. The yellow pails protect the custodial staff from accidental injury from broken glass.

B. Wafers

Check with the Process Engineering Manager before throwing away whole wafers. Some can be recycled or used as dummies for the svgcoat and/or disco saw. The Microlab supports silicon recycling. Recycled silicon is a growing commodity since it is used for photovoltaic devices. A separate container is available in Room 432 for discarded wafers and wafer pieces. Silicon with any deposited films may be placed in this container. No glass wafers or pieces are to be placed in this container.

C. Needles & Razor Blades

Needles and razor blades should be disposed of in the sharps disposal bins (red plastic containers) provided throughout the Microlab. Small glass slides may also be disposed in these containers but large glass pieces should be placed in the broken glassware pails described above. If these plastic containers are full, contact the Microlab office and they will be emptied. Do not dispose of needles or razor blades in the trash cans!

D. Broken Thermometers

Mercury thermometers are banned from the Microlab and not stocked for checkout. All thermometers stocked by the Microlab are non-mercury types. Lab members cannot bring or use mercury thermometers within the Microlab. In the event a mercury thermometer finds its way into the lab and is broken, dispose of mercury and the glass in the heavy metal waste container located at sink432b. Contact Microlab staff in the event of any mercury spill within the lab.

Non-mercury thermometers should be disposed as broken glass, in a sharps disposal bin or a yellow pail designated for broken glass.

IV. COMPRESSED GASES

A. Handling Gas Cylinders

Cylinders of both toxic and non-toxic compressed gases are in use throughout the lab. Lab members may not install or disconnect these cylinders. Only trained staff may handle any compressed gas cylinders. There are several reasons for this policy. Some gases are toxic. Some gases in these cylinders are at high pressures, some as high as 3000 psi. Regulators are designed to handle specific gases and

can explode if not properly chosen. Improper installation or purging will contaminate a full bottle of gas. Some of our etching gases cost thousands of dollars per cylinder and their loss or contamination is very costly.

Gas cylinders must be chained or strapped at all times.

B. Toxic Gases

All toxic, flammable or corrosive gases are kept in steel gas cabinets equipped with exhaust alarms. As with other cylinder gases, these gas cylinders are changed by staff-only. Toxic gases are monitored with sensors located near their point of use and routed to monitoring equipment in the HAZMAT cabinet outside the Microlab entrance.

Among the toxic gases used in the Microlab are ammonia, phosphine, and dichlorosilane gases, used in the Tylan LPCVD furnaces. Examples of corrosive gases are BCl_3 (boron trichloride), Cl_2 (chlorine), HBr (hydrogen bromide) and SiCl_4 , (dichlorosilane). These gases have characteristic odors; however, sense of smell varies with the individual. B_2H_6 (diborane) and PH_3 (phosphine) have odors which some describe as smelling like garlic or decaying fish, NH_3 (ammonia) has a pungent, acrid odor.

If you suspect a gas leak, you should evacuate the Microlab using the manual blue pull-stations of the HAZMAT alarm. As noted, the HAZMAT system will simultaneously produce an audio and visual alarm and shut off gas cylinders in the gas cabinet. NOTE: HAZMAT is a local alarm and does not call or signal 911. For more information on the HAZMAT alarm, see Section 3 under General.

C. Nitrogen Guns

Nitrogen guns and compressed gas can inflate the skin like a balloon, tearing it away from the tissue underneath. Be cautious and avoid cuts when spraying nitrogen or working around gas streams.

V. RADIATION SOURCES

A. Lasers

The use of lasers within the Microlab must be approved by the Laboratory Safety Officer. Lasers are clearly marked by class. Class I lasers may be used without special equipment. Class II, III, IV require special safety glasses with specific band pass characteristics. Special safety glasses can be procured for you through Environment, Health and Safety. In addition, class II, III and IV lasers must be safety interlocked to prevent accidental exposure. Lab members who work with class II, III and IV lasers must read training materials, and then sign a form. Documents are available in the Microlab office or at the UC Berkeley Office of Radiation Safety Laser Training website: <http://radsafe.berkeley.edu/>. Standard operating procedures must be posted near each laser in use in the Microlab.

Laser standard operating procedures, SOPs, are posted in laser rooms and available via the WAND:

CATEGORIES(space)	TASKS(space).....
* ALARM -> USE PULL-DOWN STATION!!!	. c Computer related problems
c Chemicals and Materials	. e Emergency telephone numbers
e Equipment	. E Emergency Response Plan
E Equipment Communication	. f Emergency flood procedures
g General Purpose	. C Chemical Hygiene Plan
h Help	.=>l Laser Operating Procedures
i Info. About Lab Members and Fees	. m Microlab MSDS index (:q to quit)
l Lab Manual and Your Lab Notes	. M Material Safety Data Sheets Info
m Mail and Messages	. p Equipment problems and comments
p Process Logs	. r Report a safety problem
r Reservations	. s Spill cleanup
s Sign Out of Lab	. S Microlab Safety Rules & Procedures
==>S Safety, Trouble & Prevention	.
v Visitors	.█

B. Ionizing Radiation

All ionizing radiation sources must be cleared for use with the Lab Manager. Radiation sources require a Radiation Use Authorization (RUA) issued by Environment, Health and Safety.

VI. CRYOGENS

Liquid nitrogen or "LN" is a cryogen used commonly in the lab. It is stored in vacuum jacketed cylinders called dewars. The dewars are large and heavy and should be moved with care. LNs major hazards are burns from freezing or asphyxiation due to sudden oxygen depletion. Use care and avoid spills when dispensing liquid nitrogen from a dewar to minimize damage to the lab floor due to freezing and cracking. Wear gloves and goggles when transferring LN to a smaller dewar, the only type of container appropriate for handling small amounts of cryogens.

VII. FIRE PREVENTION & RESPONSE

Fires in the lab can result from many causes, including ignition of flammable gases or solvents and combustion of materials. Use care when using heat lamps or heating flammable solvents on hot plates. Always use a water bath to transfer heat to flammable solvents when using a hot plate and never leave the water bath while the hotplate is powered up. Avoid water around electrical equipment, cables and outlets. Use common sense when working in the lab.

The Microlab has removed all analog control hotplates and uses only digital temperature controlled hotplates to avoid temperature overshoot and minimize fire hazard. Lab members must review any equipment they would like to bring in to the lab (including personal hotplates) with the Microlab Safety Office, Bob Hamilton, bob at eecs.berkeley.edu or Technology Manager Bill Flounders, bill at eecs.berkeley.edu. The present lab standard hotplate is: Fisher Scientific p/n 11-675-911Q Mfg: Thermo Scientific, Cimarec Model HP131225Q.

A. In Case of Fire

In the event of a fire in the lab, use the extinguishers and report it to the staff. Fire extinguishers are located in all rooms. Most of these are Halon type extinguishers capable of extinguishing all types of fires without damaging equipment. You will find three large Halon extinguishers beginning in the hallway by the eyewash, one by the Nanometrics microscope, and one by the Tylan service area. Carbon dioxide type extinguishers are found in the old lab. The campus Fire Department regularly checks fire extinguishers. Microlab users are not expected to be fire fighters. Use a fire extinguisher if the fire is still small. If it is spreading, do not try to be a hero: Activate the alarm and evacuate the building. Report any use of a fire extinguisher to the office immediately.

For fires, pull the red fire alarm, call 911, and evacuate the lab. If you activate the fire alarm, also pull the blue hazmat alarm. This shuts off all toxic gases. Remember if you pull red – pull blue too.

If your clothes catch fire, use the showers and do not panic. MAKE SURE YOU KNOW THE LOCATION OF THE SHOWERS AND EYE WASH STATIONS!

B. Sprinkler System

The Microlab is protected by a water type sprinkler system. This system is designed to deliver 15-gallons/minute. When water flows, an alarm is automatically sent to the fire station and firefighters will respond. In view of the potential damage to our equipment from an accidental activation, we have purchased a tool to shut a sprinkler head off by jamming it in the head. The tool is located by the gloves in the gowning area of the lab. There is also a main shutoff valve located adjacent the stairwell by the entrance to the Microlab. It has an 8-inch handle that will turn off the water when rotated clockwise. In the event of an accidental activation of the sprinkler system, shutting this valve off would help save equipment. Shutting off this valve automatically sends a fire alarm.

VIII. FLOODING IN THE LAB

If water starts flooding the floor of the lab, follow these steps:

- 1) Search for the source of the leak and turn off supply valves. The sinks in the lab have 3 sources of water: DI supply, DI return, and ICW; all three supply valves should be turned off. Equipment may have multiple sources; try and find the shut-off valves located in the service chases or on the wall in 432.
- 2) Notify a staff member who will help you clean it up. If the flooding happens after office hours, use the emergency phone list to contact a staff member.
- 3) Use the wet-vac to vacuum up the water from the floor.
- 4) Report the incident using the wand.

IX. ELECTRICAL SAFETY

All electrical power wiring is to be done by Microlab staff; report all electrical problems to staff. Learn the locations of the circuit breakers required by the equipment you use. Lab members must obey all DO NOT OPERATE and LOCKOUT tags and equipment locked messages. Do not attempt to operate any equipment with these designations. In case of electrocution of someone in the lab, do not touch or grab them until power is off. Do not attempt to shut off power on the system; rather, use the circuit breakers in the service chases or the breaker panels located on the walls of the 432 labs.

The use of power strips in the Microlab is regulated. Many locations cannot handle the increase in electrical current load when a power strip is added. Power strips may not be used as extension cords.

Safety Test Study Guide

Be sure to know...

1. Which chemicals to aspirate, which to collect in waste bottles.
2. Where to dispose of scrap wafers, broken glass, empty bottles and hazardous waste.
3. How to deal with acid spill, on you and on floor, and what to do if the lab starts flooding.
4. Policy on working alone in the lab, and how to deal with a co-worker who leaves a mess.
5. What to do when troubleshooting does not work and info to include in FAULTS report.
6. How to deal with suspicious odors and how to work with fume-producing chemicals.
7. Procedure when leaving a fumehood, labeling any process if you leave the Microlab.
10. Getting trained on new equipment, possible contaminants in the lab.
11. Safety gear you must wear in lab, at sinks, when handling clean cassettes.
12. What equipment you are allowed to use after passing safety test.
13. What items you may/may not bring into Microlab, what to do with a suspicious package.
14. How to respond to a severe injury or electric shock in the Microlab.
15. What to do if you get acid in your eyes, and when you cannot get to eyewash.
16. How to respond to hazmat alarm, fire alarm, and campus warning siren.
17. What to do if you measure out too much of a chemical.
18. In what order you add acids and water, and the hazards of mixing acids and solvents.
19. Warming a solvent solution, hazards and precautions for liquid nitrogen.
20. If you suspect your skin was exposed to HF, how to clean up an unknown spill.
21. Also, be sure to have read the EECS Injury & Illness Prevention Plan (IIPP) and the Cory Hall Building Emergency Plan (BEP) online at www.eecs.berkeley.edu/department/emergency