Center for Nano and Micro Manufacturing

Chemical Hygiene Plan

1.0 Introduction

Cal/OSHA (Title 8 CCR Sec.5191) requires that all laboratories have a written Chemical Hygiene Plan as a fundamental chemical safety document for the laboratory. Chemical Hygiene Plans are required to include laboratory specific hazards and safety information. A hierarchy of administrative controls, engineering controls, and protective equipment form the basis of the chemical hygiene plan. The procedures within this manual are for your protection and describe the available potential dangers. Your lab membership is contingent on passing the CHP test that covers material found within thismanual.

2.0 Responsible Persons

Associate Dean of Safety and Facilities: Case van Dam
cpvandam@ucdavis.edu

Safety Officer: Rijuta Ravichandran
rravicha@ucdavis.edu

3.0 Rooms Covered by this Chemical Hygiene Plan

All rooms are in Kemper Hall:

1125 Office	1246 General Lab	1204 Chemical Stock Room
1249 Microscope	1208 Shipping/Receiving	1254 Gas Storage
1274 Lab Work Room	1224 A-1-A8, B1-B4	

Service Chase:

11210	1214	1218	1222	1226
1230	1236	1240	1243	1244
1254 A-C	1260	1264	1268	1276

4.0 General Safety Information

The following safety procedures and rules must be read, understood, and practiced at all times. Users of all levels will be treated equally and are expected to carry out all operations with both the safety of the individual and other users as the primary consideration. Ignorance of the rules, lack of common sense, language difficulties, carelessness, and being short on time are not adequate excuses for unsafe behavior or poor etiquette.

Think about your actions and how they will affect other lab members, as well as yourself. Use common sense and consideration when working. 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 to the safety officer immediately. Safety is an ongoing effort. Laboratory procedures and rules continuously evolve based upon lab member input and changing laboratory conditions. If you have any questions, feel free to ask a staff member.

You are continuously being recorded while working in the facilities. Recorded violations may result in immediate suspensions for several days, weeks, or even permanently. These suspensions are at the sole discretion of CNM2 management with formal notification to the user and the principal investigator of the project. **As a general rule, anyone violating any safety rules or otherwise compromising his or her own personal safety or the safety of others will have their access to the laboratory restricted, suspended, orrevoked.**

4.1 Emergencies

The Emergency Phone Numbers list (see next page) is posted by every lab telephone and at all lab entrances. The nature of an emergency will determine whether you will call 911 or call lab staff. Call 911 or 530-752-1230 (by cell phone) for any fire, severe injury, bomb threat or any other life- threatening situation. As soon as you are safely able to do so - follow up a 911 emergency phone calls with a call to staff. When placing calls to staff, call them in the order listed until you reach a live person.

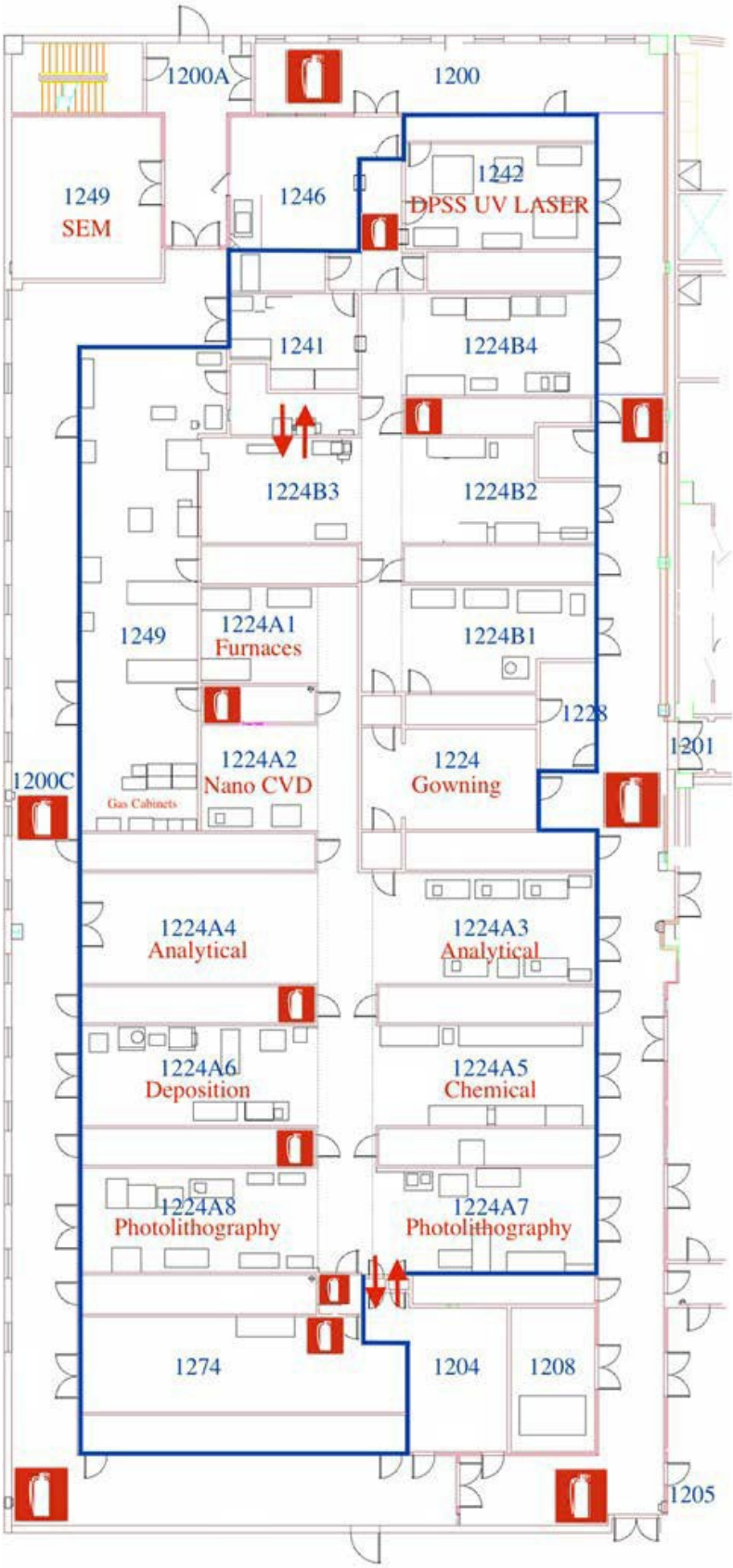
4.1.1 911 Emergency Response

Lab telephones are the best method to call 911. Using a lab phone provides emergency responders with the location of the emergency without the person calling for help having to provide it. Using a lab phone ensures that your call is immediately routed to the local emergency response station.

If you must use a cell phone to place an emergency call it is recommended that you dial Davis Campus Emergency at 530-752-1230 or UC Campus Police at 530-752-1234. This ensures that your call is routed to the local emergency response station.

Calls placed to 911 using a cell phone result in delay since they are directed to a statewide operator who must determine your location and then forward your call to the local emergency response station.

Follow all instruction of the emergency response operator.



4.1.2 Fire

In case of fire, use the red fire alarm pull boxes located at every lab exit. The campus Fire Department regularly checks fire extinguishers.

In the event of a small fire in the lab, use the extinguishers if you are comfortable doing so and report it to the CNM2 staff immediately. If you are not comfortable using a fire extinguisher, follow the directions below.

For fires, pull the red fire alarm, call 911, and evacuate the building according to the directions in Appendix B. If you activate the fire alarm, also pull the Toxic Gas Shutoff if possible (Green). This shuts off all toxic gases. Remember if you pull red – pull green too. If your clothes catch fire, use the showers and do not panic. Make sure to memorize safety shower locations.

4.1.3 Fire Prevention & Response

Lab fires can be caused by the ignition of flammable gases or solvents, and by combustion of materials. Use care when using heat lamps or heating flammable solvents. Lab members must review any equipment they would like to bring in to the lab with CNM2 Safety Officer, Corey Wolin or alternate. Avoid water around electrical equipment such as hot plates, power cables or outlets. Use common sense when working in the lab

4.1.4 Hotplates

Hotplates are a common cause of laboratory fires. Always use a water bath to transfer heat to flammable solvents when using a hotplate.

CNM2 supplies and allows only digital temperature-controlled hotplates. Lab members who want to own their own, dedicated hotplate are welcome to do so as long as the hotplate is digital. Digital hotplates avoid temperature overshoot and decrease fire hazard. CNM2 current standard hotplates are Fisher Scientific p/n 11-200-49H, an aluminum-topped isothermal hotplate used to cure photoresist and polymers, and Cimarec Model HP131225Q, a ceramic topped hotplate for use with chemicals.

Hotplates may be left unattended when performing well understood, stable processes, during regular CNM2 Staff hours (8AM – 5PM) if labeled with a blue process identification tag. Hotplates should be periodically monitored. Hotplates must be secured before finishing laboratory activities for the day. In the event a process requires hotplate use outside of regular Staff hours, members are responsible for conducting routine inspections that maintain a safe, well controlled process. Any hotplate above 200°C requires full supervision until processing is done.

4.1.5 In Case of Fire

Fire extinguishers are located in all rooms. The campus Fire Department regularly checks fire extinguishers. You are not expected to fight fires. Use a fire extinguisher only if you are trained and feel safe. **Your responsibilities are: "Notify, Evaluate, Evacuate"**. As soon as possible, Activate the fire alarm, evacuate the building, contact staff. Report any use of a fire extinguisher.

For fires, pull the red fire alarm, call 911, and evacuate the lab.

If your clothes catch fire, use the showers and do not panic. Make sure you know the location of all lab showers and eyewash stations.

4.1.6 Sprinkler System

CNM2 is protected by a water type sprinkler system. This system is designed to deliver > 15-gallons / minute per sprinkler head. When water flows, an alarm is automatically sent to the fire station and firefighters will respond.

4.1.7 Medical Emergencies

CNM2 relies on several emergency medical resources to deal with injuries or life safety issues.

- Call 911 before you call staff

when there is a serious injury or life threatening issue.

- Occupational Health, located on La Rue between Hutchison Drive and Orchard Road, across the street from the Activities & Recreation Center (ARC).
- Davis Urgent Care, address is 4515 Fermi Pl #105 Davis CA 95618, open everyday from 9am-9pm.
- Urgent Care: Sutter Davis Hospital, address is 2020 Sutter Pl #101 Davis CA 95616, Open weekdays from 5:30pm- 9:30pm and weekends from 10am-5:30pm.

5.0 Electrical Safety

Before using a power strips in the CNM2, check with a CNM2 staff person. 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, and extension cords may not be used with a power strip.

5.1 Electrical Shock

If you witness an electrical shock, DO NOT MAKE CONTACT WITH THE VICTIM WITHOUT MAKING SURE THEY ARE NO LONGER IN CONTACT WITH THE ELECTRICAL CURRENT. **If the person still has contact, assume they are not grounded. If possible, shut off the current safely and quickly. Otherwise, use appropriate non- conductive material to help you break the current.** Use extreme caution! Do not become another victim. Dial 911 Immediately and alert lab staff.

6.0 Facilities

For facility problems, such as a leak or a utility problem that does **not** represent a danger to the lab members but may result in damage to equipment, use the emergency phone list and call staff. **Do not call 911 for problems limited to facilities or equipment.**
For emergency and general building issues call Facilities trouble desk at 530- 752-1655 or submit a work order online.

7.0 Flooding in the Lab

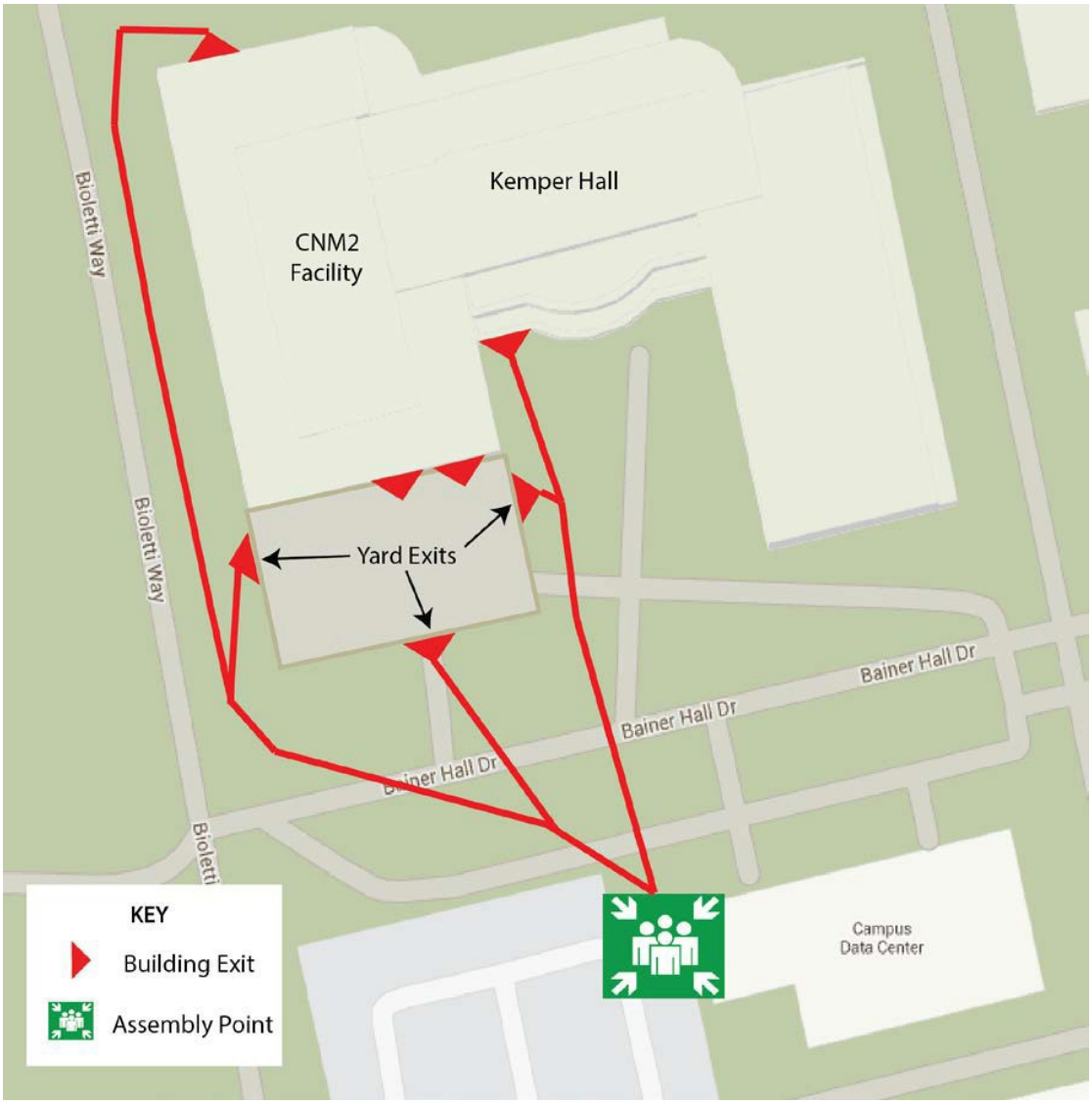
7.1 Search for the source of the leak and turn off supply valves. The sinks in the lab have three sources of water: DI supply, DI return, and ICW; all three supply valves should be turned off. Equipment may have multiple sources; try and find the shut-off valves located behind each sink or tool. If unable to determine source, or find shut off valve. Notify staff immediately!

7.2. 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 the Facilities trouble desk at 752-1655 and report it as an emergency. If unsuccessful, contact CNM2 staff using emergency phone numbers listed.

8.0 Evacuation Procedures

8.1.1 When the building fire alarm sounds you MUST evacuate the laboratory immediately through the safest route available. Advise those around you to evacuate the building. Secure your process (turn off the equipment in a safe manner), proceed to the nearest yellow exit door and leave the lab quickly but calmly. Do not worry about de-gowning.

Emergency exits are shown in the next page. Note, the main lab entrance to the gowning room is **not** an emergency exit. Unless absolutely necessary, do not evacuate the lab using the gowning room entrance door. Once you have exited the building, proceed to Emergency Assembly Area on the south side of Kemper across the courtyard near A-lot parking. If YOU are the individual that activated the fire alarm, or if you have any information related to the emergency, remain at the emergency assembly area so you can provide information to emergency responders and laboratory staff. You may not re-enter Kemper Hall or the cleanroom until all evacuation alarms and lights have been reset and the Fire Department or staff have announced “all clear” and given permission to re-enter the building.


Kemper Hall
CNM2
Facility
Bioletti Way
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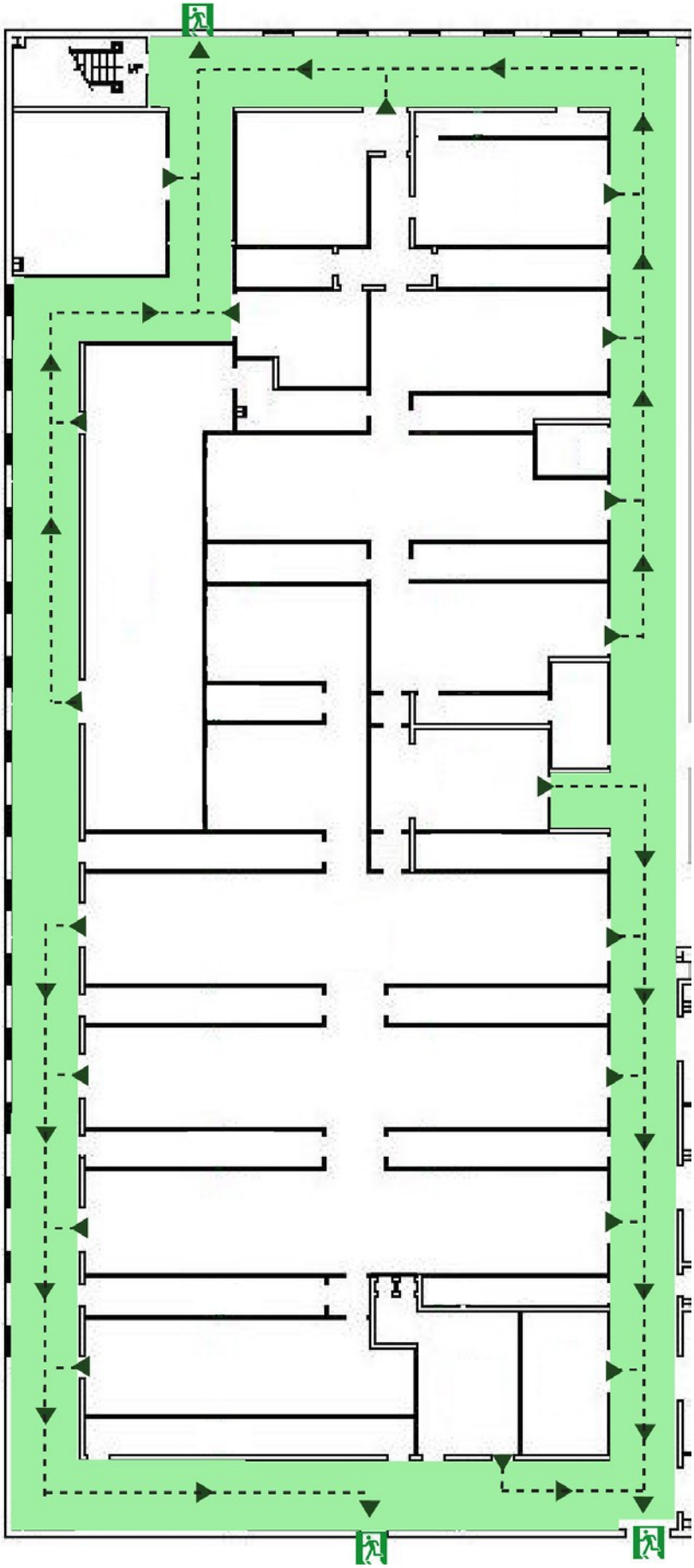
Yard Exits
Bainer Hall Dr
Bainer Hall Dr
Bainer Hall Dr
Bioletti
Campus
Data Center
KEY
Building Exit
Assembly Point



Be aware of your own and everyone else'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 to staff immediately.

8.2 Laboratory Protocols

8.2.1 Clothing

Sandals, open toe shoes, high heels and bare feet are prohibited. Shoes must cover the entire top of your foot; e.g., no ballet flats or similar shoes allowed. Shorts are only permitted when wearing the full coverall cleanroom suits.

8.2.2 Gowning

CNM2 is nominally a class-100 cleanroom environment, e.g. less than 100 particles of diameter 0.3um 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 the cleanroom environment of CNM2. Gowning begins outside the lab entrance. Place your shoe into the shoe cleaner, and then wrap a shoe cover over your cleaned shoes before stepping on the tacky mat outside the cleanroom. Then use your key code to enter the gowning room. Always keep shoe covers on while working in the gowning area, and do not remove them until after you have left the cleanroom. To enter the lab, you must also wear a re-useable Tyvek hood, Tyvek coveralls, and Tyvek boot covers. In addition, nitrile gloves and protective eyewear must be worn at all times. Face masks are also available as an option if you have facial hair or working with sensitive processes. These items are provided by CNM2 and available in the gowning room.

Gowning for CNM2 satellite laboratories are less stringent. For room 1246, you must wear a blue nomex flame retardant lab coat, protective eyewear, and nitrile gloves at all time. These items are available at the entrance of the room. For room 1249, you must wear nitrile gloves when handling your samples and equipment. Protective eyewear if cleaving or breaking wafers. Gloves and eyewear are available on the work station table in 1249.

8.2.3 Protective Eyewear

You MUST wear safety glasses when inside CNM2 and its satellite labs at all times. Only safety glasses approved by the American National Safety Institute (ANSI) and meeting the ANSI Z-87.1 standard are allowed. Safety glasses are not required while in the gowning area or in room 1249. CNM2 maintains an inventory of approved safety glasses which lab members can use but must return before leaving the lab.

For those lab members who wear prescription glasses, prescription safety glasses MUST be obtained – or you must wear safety glasses or goggles over your prescription glasses.

Wearing contact lenses in a research laboratory environment is discouraged. While UC does not have a policy forbidding the wearing of contact lenses in

combination with safety glasses, it is not recommended. Contact lenses are prone to absorbing or trapping chemicals possibly prolonging or aggravating an accidental exposure. CNM2 does not recommend wearing contact lenses with safety glasses

Certain circumstances, such as work with lasers or ultraviolet light (UV) sources may require additional eye protection. Please contact staff to review protective eyewear requirements beforehand.

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8.2.4 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 working in the cleanroom– or any laboratory. Remember that the nitrile gloves must be worn at all times while in the CNM2, and are primarily intended to protect equipment and materials from the oils, salts, and particulates that are always on your skin. Avoid touching your face with your gloved hands. Check your gloves frequently; put on fresh gloves if they become torn or contaminated.

It is campus wide EH&S policy that gloves are not to be worn outside of laboratories. This is to ensure that any contaminants that might be on your gloves are not transferred outside the laboratory when touching door handles, elevator buttons, etc. Be sure to remove all gowning items including all gloves as you depart the laboratory. It is not acceptable to keep gloves on to "protect the cleanliness" of your samples as you transfer them to another laboratory. Use plastic bags or boxes to transfer your samples.

8.2.5 Food and Beverages

Food and beverages are not allowed in any part of CNM2, its satellite labs, or service chases.

8.2.6 Cell Phones

You may only use cell phones in the gowning area, room 1249 (the SEM room), or in case of life threatening emergencies.
Cell phones must not be used within the lab or when operating equipment. Lab members are reminded to be courteous to other members when using a cell phone in the gowning area and to keep conversations to a minimum. **After using a cell phone, change your nitrile gloves to avoid contamination from perspiration and skin oils on all cell phones.**

8.2.7 Head phones

Radios, music players and headphones are not allowed while operating equipment and are prohibited in CNM2.

8.2.8 Visitors

Visitors are allowed by permission only. All visitors must be associated with the research missions of CNM2 and its lab membership. Friends and family members do not qualify as visitors. Please contact staff if you would like to bring a visitor into the lab. All visitors must remain with their host at all times. Visitors are never to operate equipment or handle chemicals. Visits are to be completed during staff hours (9am-5pm) only. In the event of evacuation, visitors are to be escorted out by their lab member hosts following all established evacuation protocols. Photography is permitted but do not use flash equipment in the yellow rooms.

8.2.9 Personal Hygiene

Avoid touching your skin, eyes, or mouth while wearing gloves. Many of the chemicals that are used in the lab are hazardous or may irritate skin. It is important to wash your hands after working in CNM2 – or any laboratory even if no known exposure has occurred. Remember, the nitrile gloves are meant to protect the cleanroom and equipment from skin oils and dirt. They are not serve adequate protection for chemical handling.

8.3 First Aid

Injuries, such as minor burns and cuts can be treated with the first aid kit located by each of the 5 Safety Stations within the lab or in the office. Injuries which require treatment by a health care professional must be documented by laboratory staff within 24 hours of medical treatment or on the Monday following a weekend. We want to know your injury has been properly treated and do everything possible to prevent another injury from occurring.

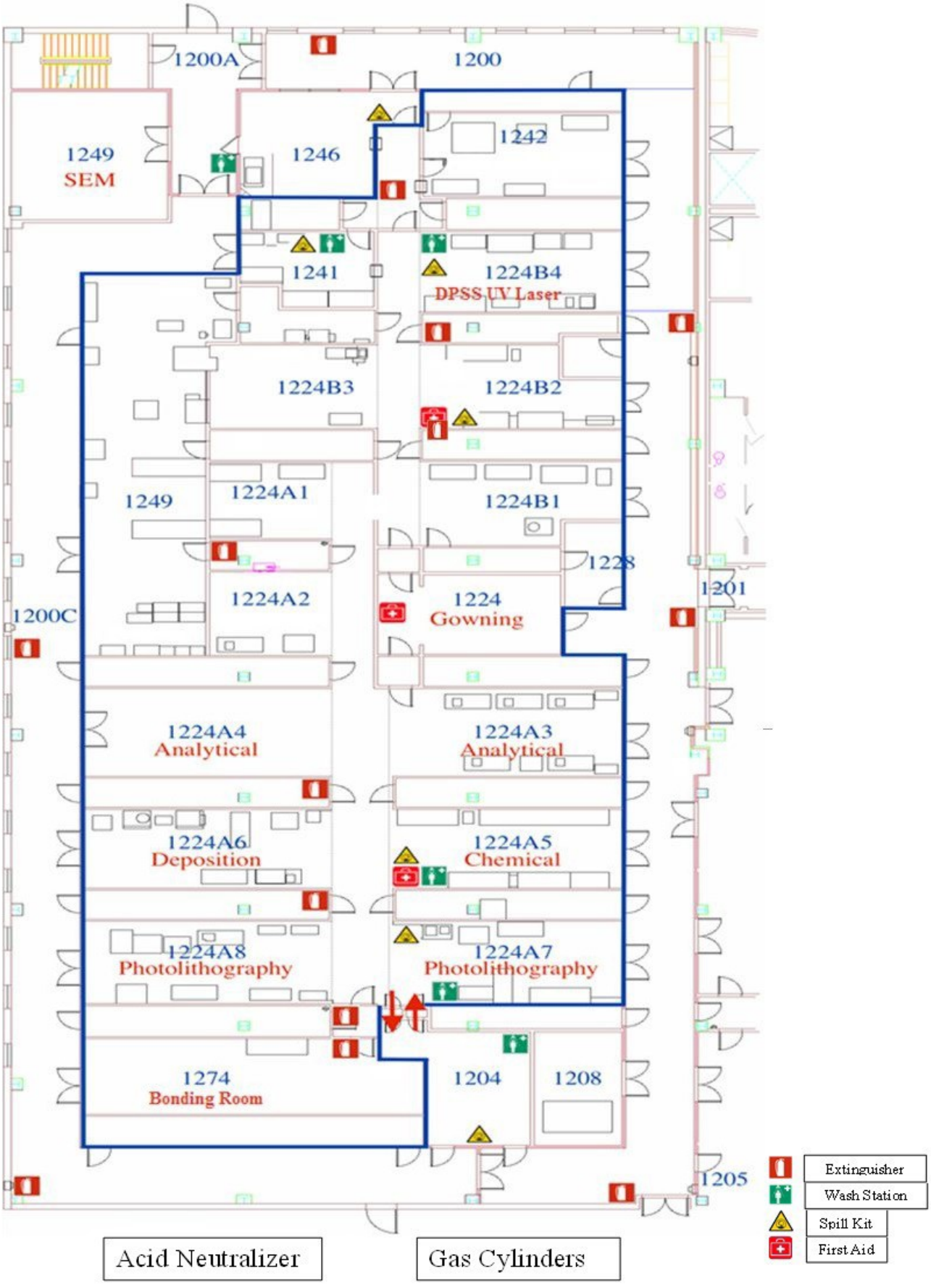
Lab members familiar with first aid should come to the aid of colleagues. California has a Good Samaritan law protecting people who give first aid from legal liability.

8.4 Safety Stations

There are 5 Safety Shower / Eyewash stations in the cleanroom and one in room 1246. Five of these shower locations have been designated as Safety Stations and are equipped with additional safety equipment. In addition to the safety shower and eyewash, each Safety Station is also equipped with the following:

- Spill Containment Kit
- First Aid Kit
- pH test strips
- HF burn paste

The locations of these stations are clearly marked with a Safety Station sign. The location of all 5 Safety Showers are shown on the layout map. Please memorize the locations of these stations so you know where to find the closest one to your working area.


1200A
1200
1249
SEM
1246
1242
1241
1224B4
DPSS UV Laser
1224B3
1224B2
1249
1224A1
1224B1
1228
1201
1200C
1224A2
1224
Gowning
1224A4
Analytical
1224A3
Analytical
1224A6
Deposition
1224A5
Chemical
1224A8
Photolithography
1224A7
Photolithography
1274
Bonding Room
1204
1208
1205
Extinguisher
Wash Station
Spill Kit
First Aid
Acid Neutralizer
Gas Cylinders

9.0 Chemical Safety

9.1 Chemical Information and Reference Materials

CNM2 lab members primarily use "standard" chemicals. These are chemicals stocked by CNM2. Chemicals stocked in CNM2 are for use in CNM2 and CNM2 managed satellite laboratories ONLY. CNM2 standard chemicals are not for use in other departments or faculty-specific research facilities.

Storage Locations				
In Chemical Bay			Photolithography	
Acids	Bases	Oxidizers	Flammables	Developers & Corrosives
Buffered Oxide Etch (BOE) 6:1 Hydrofluoric Acid (49%) Acetic Acid Hydrochloric Acid Phosphoric Acid Sulfuric Acid 98% Chrome Etchant	Ammonium Fluoride Ammonium Hydroxide (29%) Potassium Hydroxide	Hydrogen Peroxide (30%) Nitric Acid (96%)	Acetone Isopropanol Methanol PRS 3000 Hexamethyldisilazine Methylisobutylketone 1165 ThinnerP/EBR10-A NMP Toluene Shipley 1813	CD_26 MF-319 Developer

CNM2 lab members may also bring in "personal" chemicals, which consist of any chemicals that are not provided by the lab. CNM2 staff needs to be notified of all chemicals brought into the facility so that staff can immediately identify the potential hazards and ownership of the material. Please submit a "personal chemical approval" form found on our website using the MSDS (http://www.actiocms.com/chemquik/mainpage.cfm) for each chemical you plan on using and bringing into the facility, depending on the process CNM2 staff may require you to produce an SOP.

Upon staff approval, the chemical will be marked with a pink label. When writing in the chemical name it is okay to use acronyms if it is easily found on the internet, or posted on CNM2's acronym list. In the future, if the chemical is being restocked, please obtain a new label for the new bottle of material, but there is no need to resubmit a new approval request.

Any chemicals that do not have the label will be disposed of, as this poses additional hazards and takes away space from other users. If you plan on using aliquots of material and using many smaller bottles, please group them into one box with all the green approval labels on the box itself. Lastly, when you are returning your locker and permanently leaving the lab, be sure to take your chemicals with you to your own site to avoid incurring the disposal charge for your chemicals.

9.1.1 An unlabeled chemical container is a general violation of Cal/OSHA regulations and may result in a heavy fine for each such container. CNM2 staff will actively seek and dispose of any special chemical without the Approved Special Chemical label or any other unlabeled chemical containers inCNM2.

9.1.2 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 **MUST** ensure that new labels are placed on their containers, providing the new owner's name and contact information. CNM2 staff will dispose of any Approved Special Chemical if the listed owner has an extinct CNM2 account.

9.2 Chemical Storage and Movement Within CNM2

Staff-Only accessible chemicals inventory is in room 1204. Researchers are not allowed in the gas and chemical storage rooms at any time unless escorted or approved by staff. Lab member accessible Standard Chemicals are stocked in chemical safety cabinets located throughout the lab. If you need additional chemicals from these safety cabinets,

- 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 removingitems.
- Opened standard chemicals should be stored at the designated areas by the sinks or the equipment that requires that chemical.
- If the chemical you need is out of stock, notify the lab office.
- Standard chemicals and Special chemicals with a pink Approved Special Chemical label may be stored in one of the chemical safety cabinets

Working-Chemical Storage

Lab members occasionally find it both convenient and cost-effective to save chemical solutions for ongoing use. CNM2 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 members login name and contact information. CNM2 staff will dispose of any improperly stored working solutions.

9.3 Working With Chemicals

Most chemical handling is done at a fume hood or a wet process station. Working with chemicals outside of a fume hood 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 dispenses and develop tools, have engineering controls to handle fumes and prevent exposure.

9.3.1 Personal Protective Equipment

You must wear chemically-rated gloves, chemical resistant apron and a face shield when working with any chemicals in the chem bay past the yellow striped tape. The following clarifications to this rule are noted:

- If you are working at a sink, even if you are only handling wafers, chips and DI water, you must have apron and face shield; this is to provide protection from others working at the sink who may be handling acids or heatingsolvents
- Gloves, apron, and faceshield are not required for incidental use of IPA or acetone with squeeze bottles at locations away from the sinks (e.g. when wiping down the sealing surface of a vacuum chamber).
- If you are working with photoresist on a lithography process near the solvent benches. For photolithography, use two layers of thin white nitrile gloves and check for exposure continuously. If there are any signs that photoresist may have contaminated the top layer of your gloves, be sure to change them out immediately.

Gloves: Three types of gloves are commonly used in CNM2:

WHITE Nitrile Gloves (gowning room): These gloves are available in bins in the gowning room. 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 please contact staff for alternatives.

BLUE thick nitrile, Chemical Resistant (chem bay): These gloves are chemically rated and must be worn whenever you work with acids, bases, etchants, or corrosives. You can find them near the chem bay. 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.

Chemically resistant gloves are to worn as PPE only – be sure to remove the chemically resistant gloves before entering data at a computer, using door handles or using a lab phone. Use care so that your PPE is not a hazard or source of contamination to other lab members. These gloves should only be used in the chem bay, and must be discarded when touching anything outside of the chem bay.

WHITE Barrier gloves (chem bay): These gloves are available in the chem and lithography area to protect against heavy uses of solvents and organics as well as acids and bases. Organics such as acetone can readily penetrate your thin white nitrile gloves. Therefore, if you believe you may be exposed to solvents and organics put a pair of barrier gloves on

top of your thin white nitrile gloves. Always leak check your gloves before using them. To leak-check pressurize them with a nitrogen gun and inspect by listening for leaks.

9.3.2 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 occurred when a lab member has prepared a piranha solution, grasped their beaker or container in order to move it, and dropped it when discovering it was too hot to hold. Use appropriate containers and tweezers for your solutions. For instance, do not use glassware for hydrofluoric (HF) acid as HF acid will dissolve glass. Only some plastics are chemically resistant to HF and other strong acids. Examples of acid compatible plastics are Teflon and polyethylene. Some plastics have limited use temperatures; never use a plastic container on a hotplate. If you are uncertain whether or not the container material you are using is compatible with your solution, review with labstaff!
Always double-check materials for compatibility with your processing need!

It is best to be present when using your solutions, but if you need to leave your solution unattended make sure they are labeled properly. Whether you are walking away from your solution for 5 minutes or overnight, you must label your working process with:

Your name

Chemical Name

Date and expected date/time of return

Phone number for contact information

Any expected hazards to be aware of (ex. Hot, do not touch, etc.)

If you encounter an unidentified spill or solution at a sink check the pH. The pH test strips can be found in plastic dispensers located at several locations throughout the lab. 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 Chemical Spills section.

9.3.3 Chemical Waste Disposal

CNM2 liquid chemical waste streams are categorized as one of three types of waste: DRAIN DISPOSABLE, Metal Ion etchant, and Organic Hazardous Chemical Waste. Organic hazardous chemical wastes must be collected and sent to the Campus Office of Environmental, Health and Safety for disposal. If your solution contains metal ions, then it must be bottled, labeled, and collected for EH&S pickup.

Lab member chemical waste is typically generated at a sink and can be aspirated at the bench unless it contains metal ions. Choose a container that is both compatible with your process and also minimizes chemical use. Lab members may bring in their own containers but double-check for chemical compatibility. Make sure to clean up completely after you are through with your process. Leave the area as you would like to find it! Proper handling and correct disposal is detailed below.

Acids (including piranha), may be drain-disposed using an **aspirator** to remove their content from the container. An aspirator has a Teflon® tube through used to suck liquids from a container. Aspirator lines can be found on the chemical wet bench sinks.
Warning: **NEVER POUR ACID directly down a drain**: **Instead, always use an aspirator. Teflon aspirators helps with proper drain disposable waste streams.**

All solvents, developers, and photoresist waste must never be aspirated or disposed of via a drain. These organic wastes must be poured into organic waste disposal bottles located at specific sinks. **Never pour acids or bases into an organic waste bottle. An explosive reaction may result.**

9.3.4 Empty Chemical Bottle Recycling:

Empty chemical bottles must be properly rinsed and placed in designated blue bin. Do NOT leave empty chemical bottles at the sinks or on the floor. When the contents of a bottle are completely used up, be sure to rinse the bottles several times with DI water then leave the bottle uncapped in the blue bin. Use a safety carrier to transport empty bottles if made of glass. Wear a face shield, apron and chemical resistant gloves while rinsing empty bottles. Bottles do not have to be completely dried before disposal. Once the bottle has been rinsed, cross out the label with an X using a permanent marker and write “rinsed clean” on the bottle with the date.

9.3.5 Organic Waste Collection & Disposal Procedure:

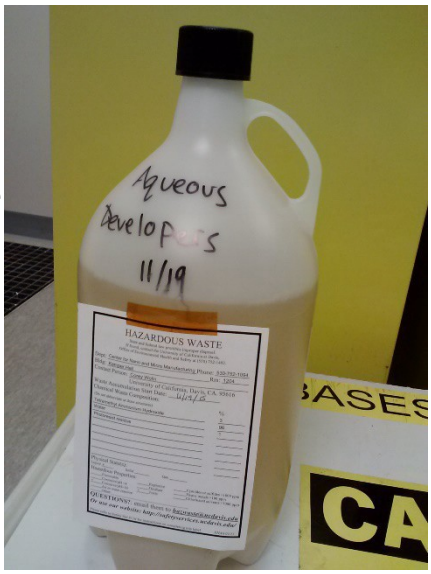
Organic hazardous chemical waste collection bottles are located by the lithography bench. These bottles are fitted with a funnel and a label that delineates them as either a “flammable” or a “aqueous developer”. The chemicals that go into the flammables bottle are solvents such as acetone, IPA, methanol, su-8 developer, thinner P, EBR 10-A. The chemicals that go into the aqueous developer bottle are strictly: TMAH, water, and any photoresist residue from

lithography processing. Never fill these bottles beyond 80%. **When a waste bottle is approximately 80% full lab members must stop making additions and immediately change out the bottle!**

To change a hazardous chemical waste bottle, remove the funnel from the bottle and replace the bottle with a cap found on the lithography sink. Take this bottle and place in the "non-acid" pass through. Then find a rinsed clean bottle from the blue recycling bin and place the funnel on the new rinsed clean bottle. Cross out the "rinsed clean" label and write "flammables" or "aqueous developers" depending on the waste bottle being replaced.

- Lab members must change bottles when approximately 80 percent full (e.g. when the bottle is full to the shoulder).
- Substitute a vented cap for the waste funnel with a vented cap. Place the associated Hazardous Waste Log Sheet into the pouch.
- If you have any questions, staff are available to change out waste bottles if you find that they are getting full.

If your solution contains metal ions, you are responsible for collecting your own waste. First check if your solution falls under any of the categories listed on the "Metal Ions Waste Disposal" sheet placed on the Acid pass-through. If it does, there should be a waste bottle on the lowest shelf for you to dispose of your solution. Otherwise, you must prepare your own waste disposal bottle. If you are unable to aspirate your solution, you must find a "rinsed" clean bottle from the blue bin. Near the acid bay there are hazardous waste tags available for you to fill out with the contents of your solution, such as, chemical name, chemical constituents and date of accumulation. After you have tagged the waste bottle with the hazardous waste tag, cross out the "rinsed clean" label on the bottle. Place the bottle into the acid pass through on the bottom shelf. **Once the bottle is approximately 80% full DO NOT FILL THE BOTTLE WITH ANYMORE SOLUTION and immediately change out the bottle!**



9.3.6 Excess and Expired Chemicals

Small amounts of excess and expired chemicals can be disposed of in their respective waste disposal containers at disposal wet bench on the research side. If there is any uncertainty regarding which container please contact lab staff for recommendations. Large quantities of expired chemicals should be turned over to lab staff in their original container. Disposal fees of non-CNM2 provided chemicals are the responsibility of the owners.

9.3.7 Lithography trash

Photoresist should not be disposed of down the drain as most photoresist contain toxic organics. There is a “flammables” and “aqueous developers” waste disposal bottle located at the lithography bay for photoresist disposal. Any wafers and other materials with photoresist should not be disposed of directly in the trash. Please dispose of them by placing in a zip lock bag that does not have any photo resist on the outside, then it can be thrown away in the trash located in the lithography area.

9.3.8 Chemical Exposure

If you are exposed to chemicals, you must immediately remove all affected clothing. For all chemical exposures, flush the area with water for at least 15 minutes. If your eyes are exposed, it is **critical** to flush them with flowing water as quickly as possible. Continue to do so **for at least fifteen minutes** to ensure diffusion. The eye’s unique shape and physiology further necessitates a thorough wash. There are 5 safety shower/eyewash stations in the lab, clearly marked with signs and mapped in Appendix A of this document.

- ► Memorize the locations of all the safety showers and eyewashes.
- ► During staff hours, contact the office or 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. All injuries occurring in the lab must be reported to staff immediately.
- ► Exposure of the eyes requires flushing with water for at least 15 minutes. All eye exposure is regarded as a serious health issue. Particular attention should be made for caustic burns from chemicals like KOH and TMAH to the eyes. Severe eye damage and blindness may result from exposure to these chemicals. As a precaution, CNM2 regards all exposures to the eye as potentially serious and requires a visit to an emergency room for a check up, following exposure and initial flushing. 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. HF typically burns beneath fingernails and cuticles, since people often forget or fail to be thorough when washing hands

for HF. 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 CNM2 First Aid Kit located at each of the 5 Safety Stations. Please see Attachment 1 for the map of CNM2 and the locations of the Safety Stations.
4. During work hours, report any HF exposure to the office.
5. If an exposure occurs after hours or on the weekends use the Emergency Phone List to contact staff. Seek medical examination immediately.

TMAH (Tetramethylammonium hydroxide) is widely used as a photoresist developer (23%) and for the anisotropic etching of silicon (10-15%). TMAH is a strong base and hazardous by ingestion, inhalation, skin (dermal) exposure and eye contact.

In addition to alkalinity-related chemical burn, dermal exposure to TMAH may also result in respiratory failure and/or cardiac arrest. A 2010 study of case reports of Taiwanese semiconductor factory injuries linked exposure of 25% TMAH to three cases of heart failure. It is important to treat TMAH skin exposure by flooding the affected area with water for at least 15 minutes and to report all exposures.

9.3.9 Chemical Spills During Staff Hours

Lab members should contain the spill using a portable Spill Containment Kit located by each of the 5 Safety Stations. The kit is a five-gallon white pail which contains spill pillows spill pads, dust pan, and plastic bags for disposal. The kit can be taken to the location of the spill. The material used in these pillows and blankets is selected for large moisture retention and its ability to neutralize acids.

► Immediately report the spill to the office.

► Used blankets and pads should be placed in a plastic hazardous waste bag and deposited in the pail. Marvell staff, trained for spill cleanup, will complete the cleanup. It is important chemical cleanup materials be disposed of properly and not in the trash containers.

safety net
UC DAVIS ENVIRONMENTAL HEALTH AND SAFETY • 2-1493

SafetyNet #13 - Guidelines for Chemical Spill

Control General Steps To Follow

1. When 1 pint or more of a hazardous material or any amount of an extremely toxic substance is spilled or when in doubt, call the UC Davis Fire Department at 9-1-1. Evacuate the room, close the door, and wait for emergency personnel.
2. If the substance spilled is flammable, turn off all ignition sources before securing theroom.
3. In case of chemical contact with skin or eyes, flood the affected area immediately with water; continue for at least 15 minutes. Seek medical assistance at Occupational Health Services located at the Cowell building or the Student Health and Wellness Center for skin irritation, contact with an extremely toxic substance, any eye injury, or any adversereactions.
4. All contaminated clothing must be removed immediately. Clothes must be laundered before reuse or disposed of as hazardous waste.
5. When incidental to one's duties, small spills (1 pint or less) may be cleaned up bylaboratory personnel. It is good laboratory practice to keep spill absorbents on hand. A good, general purpose spill absorbent is available from the Storehouse (Fisher Scientific, Cat. No.: NC9571649, DRIZORB Absorbent). Spill cleanup kits for solvents, acids, bases (caustics), mercury, hydrofluoric acid, and others are commercially available from sources such as J.T. Baker and Lab Safety Supply.
    A. Most strong acids may be absorbed and neutralized with aqueous solutions of sodium bicarbonate, calcium hydroxide (slaked lime), or sodium carbonate (soda ash). (Note: DO NOT attempt to absorb hydrofluoric acid (HF). Skip this step and neutralize immediately only if you are familiar with proper neutralization procedures for HF; otherwise, return to step one.)
    B. Caustic solutions and flammable liquids may be absorbed with an inertabsorbent.
    C. DO NOT attempt to blot cryogenic liquid spills with unprotected hands. Evacuate the space and allow the liquid to evaporate. If the cryogenic fluid evaporates to a flammable, toxic or asphyxiating gas, follow procedures (1) and (2) for largespills.
    D. Formaldehyde spills may be absorbed with an inertabsorbent.
    E. For mercury spills, see SafetyNet #16, “Guidelines for Mercury Spill Control”, for more information.
    F. Solid spills are not usually emergencies. If the material spilled is toxic, use dampened cloths or paper towels to transfer it to plastic bags. Brushing dry material may cause dust to become airborne.
6. All absorbed spill material must be collected in double plastic bags or plastic containers with secure lids and disposed of as hazardous waste. See SafetyNet #8, “Guidelines for Disposal of Chemical Waste” for more information. If the absorbent is used for a flammable or volatile compound, it must be stored in a well-ventilated area away from sources of ignition while awaiting pickup. A fume hood is a good temporary storage area.

For additional information, contact EH&S at 530-752-1493 or ehsdesk@ucdavis.edu.

When Staff Is Not Available:

- Lab members should prevent people from entering the area and contain the spill using a portable Spill Containment Kit located by each of the five Safety Stations. The kit is a five-gallon white pail which contains spill pillows, blankets, cleanroom gowns, gloves, a portable respirator and plastic hazardous disposal cleanup bags. The kit can be taken to the location of the spill. The material used in these pillows and blankets is selected for large moisture retention and its ability to neutralize acids.
- If the spill is significant or presents a serious hazard, call 9-1-1 and evacuate the lab. Make sure to inform others that are working in the lab to also evacuate. Pull the fire alarm
- Contact a staff member using the emergency contact list posted by every phone and by each entrance and exit. In all cases be sure and wash up following any spill event. File a written report on Mercury, under “Equipment” named “Safety": Marvell staff will complete spillcleanup.

9.3.10 Toxic Metals & Metal Dust

Metals, even common metals such as copper and nickel have health risks. Some metals are toxic while others are highly toxic. Therefore, CNM2 considers all metals potential health risks. When handling metals minimize the risks of ingestion and inhalation. PVD processes, such as sputtering coating, e-gun and thermal evaporations result in thin metal films depositing on the surfaces of vacuum systems which may eventually flake off. When dealing with such films never use an N2 blow-off gun to cleanup debris. Use a HEPA vacuum cleaner for cleanup. Dampened cleanroom wipes are useful. When dealing with metal film debris use reasonable caution. Metals such as Ti and Zr react and form passive oxides on exposure to air; however, full oxidation may require time for completion making these metals potentially pyrophoric (see below) and therefore an ignition source for combustibles such as clean wipes and solvents. When using wipes and particularly wipes wetted with 2-propanol make sure they are water rinsed to before disposal. When vacuuming, keep the HEPA vacuum cleaners free of combustible material such as cleanroom wipes and swabs.

9.3.11 Pyrophoric Materials

Pyrophoric materials are materials that spontaneously ignite on contact with air, oxygen, or water. Pyrophorics may also be corrosive and toxic.

Lab members who wish to bring pyrophoric reagents into the lab must first review their process with staff and receive permission to use these Special Chemicals. Do a search and review Standard Operating Procedure (SOP) for similar setups and be prepared to write a SOP for your setup. Because these precursors are intrinsic to these machines, the processes are automated, and engineering controls are in place, lab members who use these tools need only to read the lab manual and become a qualified user.

General Procedures for Handling Unreactive Hazardous Materials

☐Minimize quantities.

- Clear your work area before starting.
- Protect bench tops using disposable covering (i.e. tekwipes)
- 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 until the job is done.
- Avoid chemical etching of parts with toxic materials when possible. An etch solution containing toxic material is treated as toxic waste stream anddisposed 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 confinedust

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 285ºC. Volatile arsenic oxides form at this temperature in air. In addition, Gallium Arsenide is a hazard when ground, cut, or polished.

10 Sharps & Other Dangerous Objects

10.1 Broken Glassware

Broken glassware should be disposed of in the buckets labeled “sharps” found in each of the bays and around the labs.

10.2 Wafers

Wafer pieces, wafers with thin films deposited, or wafers contaminated with photoresist are considered sharps and can be disposed of in the “sharps” buckets found around the lab.

10.3 Needles and Razor Blades

Needles and razor blades should be disposed of in the sharps disposal bins. Do not dispose of needles or razor blades in the trash cans!

10.4 Broken Thermometers

Hg (Mercury) thermometers are banned from CNM2 and are not stocked for checkout. All thermometers stocked by CNM2 are non-Hg types. Lab members cannot bring or use thermometers within CNM2. In the event an Hg thermometer finds its way into the lab and is broken, dispose of Hg and the glass in a waste bottle and mark .
Contact CNM2 staff in the event of any Hg spill within the lab.

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

10.5 Batteries

Batteries must be disposed of by bringing them to CNM2 Office, during staff hours. Batteries cannot be discarded in trash containers.

10.6 Electronic Wastes

Electronic wastes and mercury arc lamps cannot be discarded in waste containers. Batteries should be taken to CNM2 Office for proper disposal.

11.0 Compressed Gases

11.1 Handling Gas Cylinders

Cylinders of both toxic and non-toxic compressed gases are used 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 with two non-combustible restraints at all times.

11.2 Toxic Gases

All toxic, pyrophoric, and corrosive gases are delivered from ventilated steel gas cabinets equipped with automatic gas shutoff in the event of gas detection or loss of gas cabinet exhaust flow. As with other cylinder gases, these gas cylinders are changed by staff only. Toxic, pyrophoric, and corrosive gases are monitored by the Toxic Gas Monitoring (TGM) system.

CNM2 uses the following gases which are toxic, pyrophoric, and/or corrosive: Ammonia, boron trichloride, chlorine, dichlorosilane, germane, hydrogen bromide, hydrogen chloride, phosphine, and silane. Examples of corrosive gases are BCl3 (boron trichloride), Cl2 (chlorine), HBr (hydrogen bromide) and SiCl4, (silicon tetrachloride). These gases have characteristic odors; however, sense of smell varies with the individual; e.g. PH3 (phosphine) have odors which some describe as smelling like garlic or decaying fish, NH3 (ammonia) has a pungent, acrid odor, similar to the smell of many household cleaning products.

If you suspect a gas leak, you should evacuate CNM2 using the fire alarm and advising all members remaining in the lab to also evacuate the facility.

11.3 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.

12.0 Radiation Sources

12.1 Lasers

CNM2 operates a Class I, 365 nm UV laser scribe. With the given SOP and experimental set up, there is no chance for laser exposure. If operating or maintaining the machine special training is required.

13.0 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. LN is hazardous; it can cause burns, as well as asphyxiate due to sudden oxygen depletion. Use care and avoid spills when dispensing liquid nitrogen from a Dewar to prevent damage to the lab floor. Wear gloves and goggles when transferring LN to a smaller Dewar. A Dewar is the only type of container appropriate for handling small amounts of cryogens.

14.0 Flooding in the Lab

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

14.1 **Search for the source of the leak and turn off supply valves.** The sinks in the lab have three 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 behind each sink or tool.

14.2 **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.

14.3 **Use the squeegees** located in the freight elevator vestibule area to direct water to a floor drain. Use the wet vacuum located in the freight elevator vestibule area to vacuum up any remaining water from the floor.

14.4 **Report the incident** to staff on the emergency contact lists that are posted around the lab

15.0 Electrical Safety

All electrical power wiring where voltages exceed 24 Volts may only be done by qualified CNM2 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. If someone is electrocuted in the lab, do not touch or grab them until the power has been shut off. Do not attempt to shut off power on the system; instead, use the circuit breakers located at the east end of every service chase.

The use of power strips in CNM2 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.

Acetic Acid

Process:
Acetic Acid for metal etching, polishing and surface modification.

Materials:
Acetic Acid (Glacial), sometimes diluted with water.

Incompatible Materials:
No oxidizers (such as Hydrogen Peroxide or Nitric Acid) without specific training. Be cautious of splattering due to heating if etching bulk metals or combustibles.

Hazards:
Destructive on contact with human tissues. Acetic Acid fumes will erupt from bottle and baths and are harmful to inhale. If your nose tingles from inhaled Acetic Acid, you will no longer be able to smell the fumes and should leave the area. Though typically apparent immediately, burns may take minutes to become apparent. Acetic acid is flammable, and its fumes can ignite when bath is above 40C (such as when heated due to mixing). Mixing with strong acids can lower the flammable temperature.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron. The blue disposable 'Nitridex' nitrile gloves are only splash resistant to concentrated (>40%) Acetic Acid meaning gloves should be rinsed upon exposure as it takes only 30 seconds for the acid to start working its way through the blue gloves. So keep watch for splashes and spills.

Acceptable Locations For Use:
Wet process stations 3, 8, 9, 12, 13 acid & base fume hood[2]. If hotter than a simmer, only acid & base fume hood.

Additional Process Notes:
If dilution is needed measure water, add Acetic Acid, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Beware of fumes when heating. Acetic Acid is transparent so be sure to rinse your work station after use[2]. Though Acetic acid is both an acid and an organic store it with the acids, preferably away from Nitric acid or Hydrogen Peroxide.

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Acetic Bearing Acids" bottle.

*Additional SOPs available, see: 1. PPE Choiceand Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Haz Waste Management

Ammonium Fluoride

Process:
Highly toxic mixture for etching Silicon Oxide with high selectivity to photoresist.

Materials:
Ammonium Fluoride and water for dilution, typically premixed.

Incompatible Materials:
Will slowly dissolve glassware. Mixing with acids will cause toxic HF outgassing.

Hazards:
Poor warning properties: harmful exposure and workstation contamination are initially very difficult to detect. It's also highly toxic and acutely harmful to nerves/bones. Ammonium Fluoride numbs the skin, so burns are typically not apparent until a day later. Watch very carefully for splashes because this anesthetic effect will prevent you from feeling the burn and reacting appropriately.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 3 minutes, apply Calcium Gluconate gel and call 911.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron. Ammonium Fluoride leaves persistent residues, so rinse gloves often. Keep Calcium Gluconate gel handy.

Acceptable Locations For Use:
Wet process stations 2, 3, 11, acid & base fume hood[2]. If heated only acid & base fume hood.

Additional Process Notes:
If dilution is needed measure water, add Ammonium Fluoride, then stir[3]. Room temperature Ammonium Fluoride does not pose a vapor hazard. It's very rare to heat Ammonium Fluoride, though if you do expect fume hazard to approach that of room temperature HF[4,5]. Ammonium Fluoride is transparent when wet so be sure to rinse your work station after use[2]. Its residues form toxic, white crystals when dry that can persist for years. Ammonium Fluoride's pH reads just barely above 7, turning CNM2 provided pH strips a light yellow-green. This pH is slightly higher than CNM2's DI or tap water.

Disposal:
If heated allow to cool, then decant or aspirate to neutralizer. If the solution contains heavy metals or organics, dispose of the solution in the spent "Fluorides" bottle instead[6].

*Additional SOPs available, see: 1. PPE Choice and Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Hydrofluoric Acid 6. Haz Waste Management

Aqua Regia

Process:
Aqua Regia for noble metal etches and cleaning solutions to remove trace metals and organics.

Materials:
Hydrochloric Acid (40%) and Nitric Acid (70%) in a 3:1 ratio. Sometimes DI water for dilution.

Incompatible Materials:
No Solvents. No metal powders or organic liquids as many explosive and toxic gas emitting incompatibles exist. Watch for splattering and thermal 'run away' when etching metals, combustibles, or oxidizable materials. The first sign of a runaway is an unexpected increase in bubbling, whence you should remove your sample. Mixing with Acetic acid requires special training. Use caution as many other incompatibles exist. Both Teflon and Pyrex labware are ok.

Hazards:
Destructive on contact with human tissues. Though typically apparent immediately, burns may take minutes to become apparent. Harmful Hydrogen Chloride fumes will erupt from the bottle/baths. Certain metals and organics will cause outgas of toxic brown Oxides of Nitrogen or yellow Nitrosyl Chloride. Aqua Regia leaves somewhat persistent hazardous residues. Has many dangerous incompatibles. Expect heating if mixing Aqua Regia into a spent chemical accumulation bottle, and never tightly cap bottles as pressurization and explosion will occur.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron. Aqua Regia leaves somewhat persistent invisible residues, so rinse gloves often.

Acceptable Locations For Use:
Wet process stations 3, 8, 9, 11, 12, acid & base fume hood[2]. If hotter than a simmer, only acid & base fume hood.

Additional Process Notes:
Measure water if necessary and slowly add Hydrochloric acid to water and stir. Then add Nitric Acid to water, and stir[3]. The solution may turn brown from dissolved oxides of Nitrogen. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Thin films of Aqua Regia are transparent so be sure to rinse your work station after use[2]. Never tightly cap bottles of spent Aqua Regia, which can cause an explosion. Mix a fresh bath each time because it goes bad over a few weeks and is dangerous to store.

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Persistently Oxidizing Acids" bottle[5]. Never tightly cap spent oxidizer bottles.

*Additional SOPs available, see: 1. PPE Choiceand Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4.Hotplates 5. Haz Waste Management

BOE: Buffered Oxide Etch

Process:
Highly toxic mixture for etching Silicon Oxide with high selectivity to photoresist.

Materials:
Ammonium Fluoride, Hydrofluoric Acid and water for dilution, typically premixed.

Incompatible Materials:
Will slowly dissolve glassware. Mixing with acids will cause toxic HF outgassing. Though not dangerous, metals will contaminate bath.

Hazards:
Poor warning properties: harmful exposure and workstation contamination are initially very difficult to detect. Highly Toxic and acutely harmful to nerves/bones. BOE is a skin penetrant and numbs the skin, so burns are typically not apparent until a day later. Watch very carefully for splashes because this anesthetic effect will prevent you from feeling the burn and reacting appropriately. Fumes are much less prevalent than Hydrofluoric Acid fumes, but still harmful. pH paper will not distinguish BOE from CNM2's DI water; both have pH roughly 6, causing 'no change' on CNM2's pH strips. This makes BOE spills very hard to detect, so treat unknown 'water' as BOE when working at plenums with a BOE or RCA bath.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 3 minutes, apply Calcium Gluconate gel and call 911.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex or black Chemtek)[1], and heavy chemical apron. BOE leaves persistent residues, so rinse gloves often. Keep Calcium Gluconate gel handy.

Acceptable Locations For Use:
Wet process stations 2, 3, 11, 13, acid & base fume hood[2]. If hotter than a simmer, only acid & base fume hood.

Additional Process Notes:
Never leave a BOE bath unlabeled, as it is toxic and nearly indistinguishable from DI water. If dilution is needed measure water, add BOE, then stir[3]. It's very rare to heat BOE, though if you do, expect the fume hazard to approach that of room temperature HF[4,5]. BOE is transparent when wet so be sure to rinse your work station after use[2]. Its residues form toxic, persistent white crystals when dry.

Disposal:
If heated allow to cool, then decant or aspirate to neutralizer. Heavy metal or organic bearing solutions should instead be disposed of in spent the "Fluorides" bottle[6].

*Additional SOPs available, see: 1. PPE Choice and Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Hydrofluoric Acid 6. Haz Waste Management

Ammonium Hydroxide

Process:
Ammonium Hydroxide for metal etches, surface modifications and cleaning solutions.

Materials:
Ammonium Hydroxide (29%), sometimes diluted with water.

Incompatible Materials:
No Oxidizers (such as Hydrogen Peroxide) without specific training. Be cautious of splattering due to heating if etching metals or combustibles.

Hazards:
Destructive on contact with human tissues. Though typically apparent immediately, burns may take minutes to become apparent. Harmful Ammonia fumes will erupt from bottle and baths even at room temperature. If your nose tingles from inhaled ammonia, you will no longer be able to smell the fumes and should leave the area. Ammonium Hydroxide vapors are slightly flammable, but can only typically ignite in heated enclosed containers.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron.

Acceptable Locations For Use:
Wet process stations 2, 8, 9, 11, acid & base fume hood[2]. If hotter than a simmer, only acid & base fume hood.

Additional Process Notes:
If dilution is needed measure water, add Ammonium Hydroxide, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Beware of fumes when heating. Ammonium Hydroxide is transparent so be sure to rinse your work station after use[2]. Ammonium Hydroxide is occasionally used around acids such as in the RCA process, where it becomes important to note that most Ammonium Hydroxide residues only last a few hours in cleanroom conditions.

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Ordinary Alkalis" bottle[5].

*Additional SOPs available, see: 1. PPE Choiceand Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Haz Waste Management

Hydrochloric Acid

Process:
Hydrochloric acid for metal etches and some cleaning solutions.

Materials:
Hydrochloric Acid (40%), sometimes diluted with water.

Incompatible Materials:
Be cautious of splattering due to heating and H_2 formation when etching metals or combustibles.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron.

Hazards:
Destructive on contact with human tissues. Though typically apparent immediately, burns may take many minutes to become apparent. Harmful Hydrogen Chloride fumes will erupt from bottles and baths as occasionally indicated by a fine white mist. If your nose tingles from inhaled Hydrochloric Acid, you will no longer be able to smell the fumes and should leave the area. Hydrochloric acid vapors cannot ignite unlike the vapors of Acetic Acid or Ammonium Hydroxide.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Acceptable Locations For Use:
Wet process stations 2, 3, 8, 9, 11, 12, 13, acid & base fume hood[2]. If hotter than a simmer, only acid & base fume hood.

Additional Process Notes:
If dilution is needed measure water, add Hydrochloric acid, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Beware fumes when heating. Hydrochloric acid is transparent so be sure to rinse your work station after use[2]. Hydrochloric acid is occasionally used around bases such as in the RCA process, where it becomes important to note that most Hydrochloric Acid residues only last a few hours in cleanroom conditions.

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Ordinary Acids" bottle[5].

*Additional SOPs available, see: 1. PPE Choiceand Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Haz Waste Management

Hydrogen Peroxide

Process:
Hydrogen Peroxide for etches, cleaning solutions, monolayer deposition and others.

Materials:
Hydrogen Peroxide (30% wt), sometimes diluted with water.

Incompatible Materials:
No Solvents or other liquid organics, as they tend to form explosive solids. Avoid metal powders as many explosive incompatibles exist. Be cautious of splattering due to heating[4] if etching bulk metals or combustibles. Mixing with Sulphuric Acid requires special training[3]. Use caution as many other incompatibles exist.

Hazards:
Has many dangerous incompatibles. Destructive on contact with human tissues. Produces some irritating fumes. Expect heating if mixing Hydrogen Peroxide into a spent chemical accumulation bottle, and never tightly cap bottles as pressurization and explosion will occur.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron.

Acceptable Locations For Use:
Wet process stations 2, 3, 8, 9, 11, 12, 13, acid & base fume hood[2]. If hotter than a simmer, only acid & base fume hood.

Additional Process Notes:
Measure water if necessary and slowly add Hydrogen Peroxide to water, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Never tightly cap bottles of spent Hydrogen Peroxide acid, which can cause an explosion. CNM2 provided Hydrogen Peroxide bottles come with special venting caps, which prevent these explosions. You can distinguish these caps by a tiny hole on the top and 'filter paper' on the inside. Do not cap Hydrogen Peroxide bottles with anything but a venting cap.

Disposal:
Allow to cool, then decant, or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Transiently Oxidizing Acids" bottle[5]. Never tightly cap spent oxidizer bottles with non-venting caps. Instead, leave the cap ¼ to ½ turn from tight.

Hydrofluoric acid

Process:
Highly toxic etchant for Silicon Oxide and other metal oxides.

Materials:
Hydrofluoric Acid (49%) and water for dilution, sometimes premixed.

Incompatible Materials:
Will dissolve glassware. Be cautious when mixing with acids as toxic HF outgassing will typically occur.

Hazards:
Poor warning properties: harmful exposure and workstation contamination are initially very difficult to detect. A concentrated HF splash the size of three hands can be fatal even when treated. HF numbs the skin, so diluted (<20%) HF burns are not always apparent until up to a day later. Burns from concentrated (49%) HF burns are typically immediately apparent. Fumes are prevalent, highly toxic and detectable (but just barely) at chronically harmful concentrations.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 3 minutes, apply Calcium Gluconate gel and call 911.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex or black Chemtek)[1], and heavy chemical apron. Keep Calcium Gluconate gel handy.

Acceptable Locations For Use:
Wet process stations 3, 13, acid & base fume hood[2]. If heated, only acid & base fume hood. Never open bottles or carry baths away from these ventilated areas because the toxic fumes must not be allowed to circulate through the cleanroom.

Additional Process Notes:
If dilution is needed measure water, add HF, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4].

Disposal:
If heated allow to cool, then decant or aspirate to neutralizer. Heavy metal or organic bearing solutions should instead be disposed of in spent the "Fluorides" bottle[5].

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Lift-off and Solvent Use

Process:

To clean a sample with common solvents (ex. acetone, isopropanol, methanol). Or consequently use solvents to strip resist in the lift-off process. Lab user would provide the substrate.

Materials:

There are a number of organic solvents that can be used to clean wafer and strip resist. This SOP covers the following: Acetone, Methanol, Isopropanol (IPA), Bakers PRS-3000, 1-methyl-2-pyrrolidinone (NMP), Hexamethyldisiloxane (HMDS), Dimethyl Sulfoxide (DMSO), Methyl iso-butyl ketone (MIBK), Toluene. Please check with staff before bringing in new chemicals into the lab. Lab user would provide wafer or glass samples to be cleaned or stripped of materials.

Incompatible Materials:

Oxidizers, strong acids, and bases. May fog or cause plastics to swell upon contact.

Hazards: Flammables. Many are irritants, skin penetrators, and may cause health issues long-term. Be sure to check MSDS for the exact chemicals you are working with (ex. methanol can blind you).

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 mins and seek medical attention.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical attention

Personal Protective Equipment:

Wear protective eyewear including splash goggles for using baths. Wear double nitrile gloves or use barrier gloves. If the top glove layer becomes contaminated, immediately discard the top glove and washhands.

Acceptable Locations for Use:

The photolithography area sinks, are the only areas for acceptable use. If using small amounts of acetone, IPA, or methanol, from a squeeze bottle onto a tekwipe, it is ok to use these away from the wetbenches. Lift-off or solvent cleaning baths must be done at the appropriate wet bench work stations.

Additional Process Notes:

Use Teflon or glassware for processing materials. Any deviations from existing processing protocols should be discussed with staff beforehand.

Disposal:

All materials contaminated with solvents should be placed in a zip-lock bag and can be thrown in the regular trash.
Any wafers or glass that has solvents on it should be placed in the sharps container.
Lift-off and cleaning solutions (Acetone, NMP, etc) should be disposed in the "Flammables" bottle and rinse all glassware in the sink with 3 DI water rinses. MAKE SURE THE FUNNEL IS CLOSED after pouring solution into the bottle.

Nitric Acid

Process:
Nitric Acid for metallic thin film etches, cleaning solutions and others.

Materials:
Nitric Acid (70% wt), sometimes diluted with water.

Incompatible Materials:
No Solvents or other liquid organics, which tend to form unstable explosive solids. Absolutely no metal powders as many explosive and toxic gas emitting incompatibles exist. Be cautious of splattering due to heating if etching bulk metals or combustibles. Mixing with Acetic acid requires special training[3]. Use caution as many other incompatibles exist.

Hazards:
Destructive on contact with human tissues. Burns take many minutes or hours to become apparent. Fumes will erupt from the bottle/baths, and are potent irritants to skin, eyes, and respiratory tissue. Leaves somewhat persistent hazardous residues. Has many dangerous incompatibles. Will occasionally emit a toxic brown gas called "Oxides of Nitrogen" or NO2 when heated or mixed with metals or acids. When inhaled, NO2 will block your sense of smell so you should leave the area immediately. Expect heating if mixing Nitric acid into a spent chemical accumulation bottle, and never tightly cap bottles as pressurization and explosion will occur.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex or orange Trionic)[1], and heavy chemical apron. Nitric acid leaves invisible residues, so rinse gloves often.

Acceptable Locations For Use:
Wet process stations 3, 9, 12, 13, acid & base fume hood[2]. If heated, only acid & base fume hood.

Additional Process Notes:
Measure water if necessary and slowly add Nitric Acid to water, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Nitric acid is transparent so be sure to rinse your work station after use[2]. Never tightly cap bottles of spent Nitric Acid, which risk explosion. Though Nitric Acid is both acid and oxidizer store it with the Acids, preferably away from Acetic Acid.

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Persistently Oxidizing Acids" bottle[5]. Never tightly cap spent oxidizer bottles. Instead, leave the cap ¼ to ½ turn from tight.

*Additional SOPs available, see: 1. PPE Choiceand Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Haz Waste Management

Phosphoric Acid

Process:
Phosphoric acid for Silicon Nitride (Si3N4) etch, cleaning solutions and others.

Materials:
Phosphoric Acid (85% wt), sometimes diluted with water.

Incompatible Materials:
Be cautious of splattering due to heating when etching bulk metals, combustibles, or materials that will easily oxidize. Use caution as other incompatibles exist.

Hazards:
Destructive on contact with human tissues. Burns take many minutes or hours to become apparent. Fumes from boiling baths are irritants to skin, eyes, and respiratory tissue. Leaves difficult to notice hazardous residues that persist for many months to years in a cleanroom environment. Boiling baths of Phosphoric acid (as sometimes used for Silicon Nitride etching) will often entrain Phosphoric acid in the steam, creating an enormous vapor and residue hazard. When the steam settles on a surface it remains as Phosphoric Acid residues.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron. Phosphoric acid leaves invisible residues, so rinse gloves often.

Acceptable Locations For Use:
Wet process stations 2, 3, 8, 9, 11, 12, 13, acid & base fume hood[2]. Baths hotter than 120C in acid & base fume hood.

Additional Process Notes:
Measure water if necessary and slowly add Phosphoric Acid to water, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Phosphoric acid is especially difficult to mix into water, so allow 20 seconds to completely mix. Phosphoric acid is transparent and difficult to completely rinse away with water, so be diligent when cleaning work station[2].

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions or bulk organics should instead be disposed of in the "Acids" bottle[5].

PAN: Phosphoric, Acetic and Nitric Acids

Process:
PAN for Aluminum Etch and some cleaning solutions.

Materials:
Phosphoric Acid (85% wt), Acetic Acid (Glacial), Nitric Acid (70%) and DI water in a 16:1:1:2 volumetric ratio.

Incompatible Materials:
No Solvents or other organic liquids as many explosive and toxic gas emitting incompatibles exist. Be cautious of splattering and brown toxic NO_2 outgassing when etching metals, combustibles, or materials that will easily oxidize. Use caution as many other incompatibles exist.

Hazards:
Destructive on contact with human tissues. Emits some harmful fumes. Certain metals and organics will cause dark brown toxic Oxides of Nitrogen to outgas. PAN leaves persistent hazardous residues. Has many dangerous incompatibles. Expect heating if mixing PAN into a spent chemical accumulation bottle, and never tightly cap bottles as pressurization and explosion will occur.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron. PAN leaves persistent invisible residues, so rinse gloves often.

Acceptable Locations For Use:
Wet process stations 3, 12, acid & base fume hood[2]. If hotter than a simmer, only acid & base fume hood.

Additional Process Notes:
Start with 2 parts water, then pour in 1 part Acetic Acid, followed by 1 part Nitric Acid, and finally 16 parts Phosphoric Acid. Stir between each step to avoid splatter. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Though PAN can turn brown, it's often transparent so be sure to rinse your work station after use[2]. Never tightly cap bottles of spent PAN or risk explosion.

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal (or Aluminum) bearing solutions should instead be disposed of in the "Persistently Oxidizing Acids" bottle[5]. Never tightly cap spent oxidizer bottles. Instead, leave the cap ¼ to ½ turn from tight.

Piranha

Process:
Piranha for cleaning, etch and surface preparation.

Materials:
Sulphuric Acid (98% wt), and Hydrogen Peroxide (30% wt), mixed in a 4:1 ratio by volume.

Incompatible Materials:
No Solvents or other liquid organics, which often form explosives in Piranha. Use caution as other incompatibles exist. Watch for splattering and thermal 'run away' when etching metals, combustibles, or oxidizable materials. The first sign of a runaway is an unexpected increase in bubbling, whence you should remove your sample. Both Teflon and Pyrex beakers are suitable for use with Piranha.

Hazards:
Has many dangerous incompatibles. Highly destructive on contact with human tissues. Solution bubbles and produces irritating fumes from decomposition. Piranha heats considerably upon mixing and even more so during use, often to the point of boiling and occasionally to the point of spattering. Expect still further heating if mixing Piranha into a spent chemical accumulation bottle, and never tightly cap bottles as pressurization and explosion will occur.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron. Piranha leaves invisible residues, so rinse gloves often.

Acceptable Locations For Use:
Wet process stations 2, 3, 8, 9, 11, 13, acid & base fume hood[2]. If heated, only acid & base fume hood.

Additional Process Notes:
Reacts to form some Peroxymonosulphuric acid when mixed. To mix piranha, we recommend slowly pouring the Sulphuric Acid into the Hydrogen Peroxide. However, it's ok to mix in the reverse order as some institutions suggest, though expect some spattering if you do. The concentrations of chemicals provided by CNM2 allow either order of mixing. Measure water if necessary and slowly add Hydrogen Peroxide to water, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Never tightly cap bottles of spent Piranha, which risks explosion.

Disposal: Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Transiently Oxidizing Acids" bottle[5]. Never tightly cap spent oxidizer bottles with non-venting caps. Instead, leave the cap ¼ to ½ turn from tight.

Potassium Hydroxide

Process:
Potassium Hydroxide for silicon anisotropic wet etches, cleaning solutions and others.

Materials:
Potassium Hydroxide (45% wt), sometimes diluted with water or Isopropanol.

Incompatible Materials:
Be cautious of splattering due to heating if etching bulk metals or combustibles. Potassium Hydroxide will very slowly etch glassware so Teflon and Polypropylene labware is preferred, though glassware is still acceptable if circumstances demand it.

Hazards:
Destructive on contact with all human tissues. Burns take many minutes or hours to become apparent. When etching (particularly Silicon) produces Hydrogen gas bubbles, which are flammable and sometimes explosive immediately above the bath. Leaves hazardous residues in the form of white crystals, which can persist for years. Potassium Hydroxide does not create a vapor hazard, even when heated. However if it's vigorously boiled it can entrain Potassium Hydroxide in the steam, which creates an enormous vapor and residue hazard.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron.

Acceptable Locations For Use:
Wet process station 4, 10 and acid & base fume hood[2]. Baths hotter than 60C in one of the dedicated 'KOH' baths or in the acid & base fume hood.

Additional Process Notes:
Measure water if necessary and slowly add Potassium Hydroxide to water, then stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Potassium Hydroxide is transparent when wet and leaves persistent solid residues, so be diligent when cleaning work station[2].

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions or bulk organics should instead be disposed of in the "Ordinary Alkalines" bottle located in the spent process fluid collection area[5].

RCA1 (Base)

Process:
Cleaning of non-metallic substrates

Materials:
Water, Hydrogen Peroxide (30% wt), and Ammonium Hydroxide (29% wt) in a 5:1:1 volume ratio.

Incompatible Materials:
No Solvents or liquid organics, which occasionally form explosives in RCA1. Watch for splattering and thermal 'run away' when etching metals, combustibles, or oxidizable materials. The first sign of a runaway is an unexpected increase in bubbling, whence you should remove your sample. Use caution as many other incompatibles exist. Rinse wafers in DI water between each RCA step.

Hazards:
Destructive on contact with human tissues. Ammonia fumes will erupt from the bottle/baths, and are potent irritants to skin, eyes, and respiratory tissue. RCA1 heats considerably upon mixing and even more so during use, though typically won't splatter as a result. Expect still further heating if mixing RCA1 into a spent chemical accumulation bottle, and never tightly cap bottles as pressurization and explosion will occur. RCA1 is both a base and an oxidizer, so there are many dangerous incompatibles.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron.

Acceptable Locations For Use:
Wet process stations 2, 3, 8, 9, 11, and acid & base fume hood[2]. If heated, only acid & base fume hood or dedicated RCA benches[6].

Additional Process Notes:
Measure water, add Ammonium Hydroxide, mix thoroughly, add Hydrogen Peroxide, mix again and then heat if desired [3]. If using a dedicated RCA bath, you may add Hydrogen Peroxide after heating, but must be very cautious to avoid spatter[4,6]. It's also ok to mix in the Hydrogen Peroxide and Ammonium Hydroxide in reverse order as some institutions suggest, though expect some spattering if you do. RCA1 is transparent so be sure to rinse your work station after use[2]. Never store in closed container. To maximize effectiveness, only use dedicated Teflon 'RCA' labware.

Disposal:
Allow to cool, then decant or aspirate to neutralizer. If solution contains heavy metals, dispose in the 'Transiently Oxidizing Bases' bottle[5].

*Additional SOPs available, see: 1. PPE Choice and Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Haz Waste Management 6. RCA Baths

RCA2 (Acid)

Process:
Cleaning of non-metallic substrates

Materials:
Water, Hydrogen Peroxide (30% wt), and Hydrochloric Acid (40% wt) in a 5:1:1 volume ratio.

Incompatible Materials:
No Solvents or liquid organics, which occasionally form explosives in RCA2. Watch for splattering and thermal 'run away' when etching metals, combustibles, or oxidizable materials. The first sign of a runaway is an unexpected increase in bubbling, whence you should remove your sample. Use caution as many other incompatibles exist. Rinse wafers in DI water between each RCA step.

Hazards:
Destructive on contact with human tissues. Hydrogen Chloride fumes will erupt from the bottle/baths, and are potent irritants to skin, eyes, and respiratory tissue. RCA2 heats considerably upon mixing and even more so during use, though typically won't splatter as a result. Expect still further heating if mixing RCA2 into a spent chemical accumulation bottle, and never tightly cap bottles as pressurization and explosion will occur. RCA2 is both a base and an oxidizer, so there are many dangerous incompatibles.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron.

Acceptable Locations For Use:
Wet process stations 2, 3, 8, 9, 11, and acid & base fume hood[2]. If heated, only acid & base fume hood or dedicated RCA baths[6].

Additional Process Notes:
Measure water, add Hydrochloric Acid, mix thoroughly, add Hydrogen Peroxide, mix again and then heat if desired [3]. If using a dedicated RCA bath, you may add Hydrogen Peroxide after heating, but must be very cautious to avoid spatter[4,6]. It's also ok to mix in the Hydrogen Peroxide and Hydrochloric Acid in reverse order as some institutions suggest, though expect some spattering if you do. RCA2 is transparent so be sure to rinse your work station after use[2]. Never store in closed container. To maximize effectiveness, only use dedicated Teflon 'RCA' labware.

Disposal:
Allow to cool, then decant or aspirate to neutralizer. If solution contains heavy metals, dispose in the 'Transiently Oxidizing Acids' bottle[5].

*Additional SOPs available, see: 1. PPE Choice and Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Haz Waste Management 6. RCA Baths

SulphoNitric

Process:
SulphoNitric for cleaning, etch and surface preparation.

Materials:
Sulphuric Acid (98% wt), and Nitric Acid (70% wt), mixed in a 3:1 ratio by volume. Typically heated.

Incompatible Materials:
No Solvents or liquid organics, which very frequently form explosives in SulphoNitric. Use caution as many other incompatibles exist. Watch for splattering and thermal 'run away' when etching metals, combustibles, or oxidizable materials. The first sign of a runaway is an unexpected increase in bubbling, whence you should remove your sample. Both Teflon and Pyrex beakers are suitable for use with unheated SulphoNitric, though only Pyrex can be used on hotplates.

Hazards:
Has many dangerous incompatibles. Highly destructive on contact with human tissues. Solution bubbles and produces toxic brown Nitrogen Dioxide fumes from decomposition. SulphoNitric heats upon mixing and is typically boiled during use. When simmering or boiling, SulphoNitric creates fumes and steam which entrains Sulphuric acid and creates widespread and long-lasting hazardous residues. Expect considerable heating if mixing SulphoNitric into a spent chemical accumulation bottle, and never tightly cap bottles as pressurization and explosion will occur.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and heavy chemical apron. Boiling SulphoNitric in particular leaves many hazardous residues, so rinse gloves often.

Acceptable Locations For Use:
Wet process stations 3, 9, 12 acid & base fume hood[2]. If heated, only acid & base fume hood.

Additional Process Notes:
Measure Sulphuric Acid, pour in Nitric Acid and stir[3]. Heat only after mixing is complete if greater than ambient temperature is desired[4] to avoid spatter. Never tightly cap bottles of spent SulphoNitric, which risks explosion. Clean the process station fastidiously after use to protect the next user. Also, be careful not to confuse SulphoNitric with Piranha and dispose in the wrong bottle- toxic brown Nitrogen Dioxide may erupt out as aresult.

Disposal: Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Persistently Oxidizing Acids" bottle. To avoid a waste bottle explosion, always use a venting cap or leave the cap ¼ to ½ turn from tight.

*Additional SOPs available, see: 1. PPE Choiceand Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Haz Waste Management

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Sulfuric Acid

Process:
Sulfuric Acid for cleaning solutions etches and metal polishing,

Materials:
Sulfuric Acid (98%), sometimes diluted with water.

Incompatible Materials:
No Oxidizers (such as Hydrogen Peroxide or Nitric Acid) without specific training. Be cautious of splattering due to heating if etching metals or combustibles.

Hazards:
Destructive on contact with human tissues. Though typically apparent immediately, burns may take minutes to become apparent. Leaves difficult to notice hazardous residues that persist for many months to years in a cleanroom environment.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical aid if irritation persists.

Personal Protective Equipment:
Wear goggles, face shield, heavy chemical gloves (blue disposable Nitridex)[1], and a heavy chemical apron. The blue disposable 'Nitridex' nitrile gloves are only splash resistant to concentrated (>40%) Sulphuric Acid, meaning gloves should be rinsed upon exposure because it takes only 30 seconds for the acid to start leaking through the blue gloves- So keep watch for splashes and spills.

Acceptable Locations For Use:
Wet process stations 2, 3, 8, 9, 11, 12, 13, acid & base fume hood[2]. If hotter than a simmer, only acid & base fume hood.

Additional Process Notes:
If dilution is needed measure water, add Sulfuric Acid, then stir[3]. Sulfuric acid has a particular tendency to spatter when mixed in reverse order. Heat only after mixing is complete if greater than ambient temperature is desired[4]. Sulfuric acid is especially difficult to mix into water, so allow 20 seconds to completely mix. Sulfuric acid is transparent and difficult to completely rinse away with water, so be diligent when cleaning work station[2].

Disposal:
Allow to cool, then decant or aspirate to neutralizer. Heavy metal bearing solutions should instead be disposed of in the "Ordinary Acids" bottle.

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Tetramethylammonium Hydroxide (TMAH)

Process:

To dissolve remaining photoresist from a wafer or glass substrates using 50-300mL solution.

Materials:

<3% TMAH with 97-98% water solution from the manufacturer (ex. CD-26, MF-319, etc). Lab member provides glass or wafer substrates that is coated with photoresist.

Incompatible Materials:

Plastics, organic solvents, oxidizing agents, and strong acids

Hazards: corrosive on contact, acutely toxic in high concentration. Wash hands after use

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 mins and call 911 as soon as possible
Skin: Remove splashed clothing, wash for 15 minutes and seek medical attention

Personal Protective Equipment:

Wear protective eyewear, double glove or use barrier gloves. If the top glove layer becomes contaminated, immediately discard the top glove and wash hands.

Acceptable Locations For Use:

The photolithography area sinks are the only location available for developer use.

Additional Process Notes:

Use Teflon or glassware for processing materials. User must pour solution into a clean glassware, place sample into the solution for a period of time. Then after pulling the sample from the solution, rinse with DI water and dry with nitrogen. Any deviations from existing processing protocols should be discussed with staff beforehand.

Disposal:

After development, pour solution into disposal bottle labeled "Aqueous Developers" and rinse all glassware in the sink with 3 DI water rinses. MAKE SURE THE FUNNEL IS CLOSED after pouring solution into the bottle.

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Photo- or EBL- resist (epoxy resin) handling

Process:

To coat a sample (glass, wafer, etc.) in a photosensitive or electron sensitive compound. This substrate will be baked, treated with light, and then placed in a developer solution as determined by lab member.

Materials:

A wide variety of chemicals fit the criteria of a photo or electron sensitive compound that are used within the facility. CNM2 primarily provides Shipley 1813 (propylene glycol monomethyl ether acetate-75%, cresol novolak resin 15%, photoactive compound and other esters-10%). Other chemicals will need to be submitted through the chemical approval process, since some may contain harmful solvents. Lab member provides substrates.

Incompatible Materials:

Oxidizers, strong acids, and bases. Epoxy resin is usually mixed with an organic solvent. For Shipley 1813, the main solvent used is propylene glycol monomethyl ether acetate (PGMEA).

Hazards: Solvent within resist may have specific hazards, check the MSDS. Once the solvent has been removed through baking the hazards are reduced.

Exposure Actions: Do what's below, and then notify CNM2 staff within a few hours. For advice, call CNM2 staff.
Eyes: Hold eyes open in running eyewash station for 15 mins and seek medical attention.
Skin: Remove splashed clothing, wash for 15 minutes and seek medical attention

Personal Protective Equipment:

Wear protective eyewear, double glove or use barrier gloves. If the top glove layer becomes contaminated, immediately discard the top glove and wash hands.

Acceptable Locations For Use:

The photolithography area sinks, and noted lithography equipment areas are the only areas for acceptable use. Equipment: spin coater, aligner, stepper, or EBL writer, tweezers for handling.

Additional Process Notes:

Use Teflon or glassware for processing materials. Any deviations from existing processing protocols should be discussed with staff beforehand.

Disposal:

All materials contaminated with photoresist should be placed in a zip-lock bag and can be thrown in the regular trash.
Any wafers or glass that has photoresist materials on it should be placed in the sharps container. After development, pour solution into disposal bottle labeled "Aqueous Developers" and rinse all glassware in the sink with 3 DI water rinses. MAKE SURE THE FUNNEL IS CLOSED after pouring solution into the bottle. **Lift-off solutions (Acetone, NMP, etc) should be disposed in the "Flammables" bottle.**