

GENERAL LABORATORY RULES

- Only authorized users and their escorted guests may enter the laboratories
- Report all injuries promptly
- Report all malfunctions or equipment damage promptly
- Do not use equipment or chemicals without prior training
- Do not remove any equipment from the lab without permission from a supervisor
- Do not change the settings on systems and instruments without permission
- All new chemicals introduced into the lab must be approved and properly logged in the Safety Plan
- Return items to their proper storage locations and keep work areas clean
- The last person to leave the lab each workday is responsible for shutdown or for assigning shutdown to a coworker
- If you are uncertain about a procedure or hazard, ASK FOR HELP
- No food or personal items in DH 115. No food in DH 110 except at the computer desk
- Never hesitate to admit that you have made a mistake. This can prevent equipment damage and personal injuries

Current supervisors are Dr. Troy Nagle (5-3578) and Stefan Ufer (5-4082)

EMERGENCY RESPONSES

Chemical Spills

If large quantities (> 1 liter) of any hazardous material are spilled:

- 1) Evacuate facility
- 2) Attend to personnel who may have been exposed
- 3) Call Public Safety (5-3333)
- 4) Notify supervisor (Stefan Ufer, 5-4082)
- 5) Do not re-enter facility until cleared by supervisor and the Emergency Response Commander

Solvent spills:

- 1) Eliminate sources of ignition or sparks, but avoid switching any equipment on or off
- 2) Go to nearest spill kit and apply spill pillows
- 3) Transfer pillows to plastic bag
- 4) Contact supervisor (Stefan Ufer, 5-4082) and call Hazardous Materials (5-6863) for waste disposal

Acids and base spills (except HF):

- 1) Shut off recirculation fans (blowers) on hoods
- 2) Go to nearest spill kit and apply spill pillows
- 3) Wearing acid resistant garments, transfer pillows to exhausted acid fume hood
- 4) Wash area with water
- 5) Contact supervisor (Stefan Ufer, 5-4082) and call Hazardous Materials (5-6863) for waste disposal

Hydrofluoric acid (HF) spills:

- 1) Shut off recirculation fans (blowers) on hoods
- 2) Go to nearest spill kit and apply HF neutralizer, from the perimeter of the spill inward.
The neutralizer will convert to a powder as acid is neutralized

- 3) Wearing acid resistant garments, scoop powder into a plastic bag
- 4) Was area with soap and water
- 5) Contact supervisor (Stefan Ufer, 5-4082) and call Hazardous Materials (5-6863) for waste disposal

CAUTION: If any acids or bases contact your skin or clothes, use emergency showers or eyewashes. Remove clothing when necessary while under shower.

Electrical Shock

- Remove source of energy. Shut off breaker or Emergency Power Off if possible. Use a long wooden handle or dry towel when moving live conductors.
- Check victim for pulse and breathing

Swallowed Poisons

- Call the Poison Control Center (800-672-1697)

Bleeding

- While wearing clean gloves, hold a clean cloth pad directly on wound and apply direct pressure. Do not apply a tourniquet.

Fractures

- Do not move victim unless absolutely necessary

Thermal Burns

- Do not attempt to remove clothing

IN ANY EMERGENCY CALL PUBLIC SAFETY IMMEDIATELY

5-3333

And notify a supervisor as soon as possible.

EVACUATION PLAN

There are two types of evacuation

- 1) General – all building occupants must evacuate
- 2) Local – occupants of the laboratory must evacuate

The general evacuation routes for the BMMSL are marked on the evacuation plan maps shown in the following pages. Building residents should gather outside at the NW corner of Lampe and Stinson Streets and await further instructions. Public Safety or Environmental Health and Safety will advise occupants when it is safe to return. Whenever possible, turn off all power and gas lines and close all doors before evacuating.

Local evacuations do not always require exit from the building. Occupants of the lab should gather outside the lab entrance and await further directions. Avoid hindering any emergency operations in progress.

In any evacuation, do not leave the designated meeting area. Your absence will be interpreted that you are still in the danger area and one or more persons may risk their lives looking for you.

When to Evacuate

1. Fire of any nature: Activate pull station and proceed with general evacuation of the building. Phone Public Safety (5-3333) from another building immediately.

2. Chemical spill: Since small quantities of chemicals are typically handled in the lab, spills are likely to be relatively small in volume, and may not require evacuation. Spills of fuming acids (e.g., HCl) or volatile organics (e.g., XXX) may require local evacuation with re-entry when the spill is properly contained and cleaned up.
3. Gas leak from cylinders or gas line: The scale of evacuation will depend on the seriousness of the leak and nature of gas. If the gas is toxic (e.g., XXX), reactive (e.g., XXX), corrosive (e.g., XXX), or highly flammable (e.g., oxygen), general evacuation should proceed. Less reactive gases (e.g., nitrogen) may dictate local evacuation. In the event of any gas leak, notify the lab manager and follow laboratory standard operating procedures (pp. X–X).
4. Power interruption: If the fume hood blowers are not functioning when the hood is in use due to power interruption, make sure switches to fume hoods are left ON, fully pull down sash, and immediately proceed with local evacuation. Close lab entrance door. Do not enter room after power is restored; wait until notified by Public Safety or Environmental Health and Safety that it is safe to return.

Training and Certification

This safety plan (including the *Safety in Academic Chemistry Laboratories* booklet) will serve as one of the instructional tools to inform persons working in this laboratory of hazards and procedures necessary to foster a safe work environment. Additionally, there is a Biomedical Microsensors Laboratory (BMMSL) safety manual which contains information such as general laboratory protocol and safety procedures. Training will be provided to each individual before that individual is allowed to work in this laboratory. Each person will be given (either individually or as a group) a lecture which will cover the following areas:

1. Hazard awareness for all chemicals in the area
2. Use of Material Safety Data Sheets (MSDS)
3. Permissible exposure limits to chemicals in the area
4. Signs and symptoms of exposure for each chemical in the area
5. Location of reference sources
6. Methods and observations to detect the presence or release of hazardous materials
7. Function-specific work practices
8. Emergency procedures
9. Selection, care, and use of available or required personal protective clothing or equipment
10. Emergency procedures consisting of actions to be taken by area personnel in the event of a fire, a chemical spill, an accident or other potential emergency situations
11. A question and answer session covering any safety related issues desired

A copy of the entire safety plan and the BMMSL safety manual will be made available to each person for reference and study. A safety and procedure test for the laboratory based on this information must be taken and passed within two weeks of the lecture and before the person will be allowed to work in this laboratory. During January of each year, each user must take and pass another safety test to re-certify themselves in this laboratory. After passing the safety and procedure test, each user must sign three copies of the Safety Training Certification (shown on the following page). One copy will be returned to the trained person, one copy will be filed in the laboratory, and one copy will go to the department personnel file.

HAZARDOUS MATERIALS

Compressed Gases

Gas Procurement

All hazardous and flammable gases must be maintained in a designated, ventilated cabinet in a gas storage room. Gases for a system may be ordered after completion of a XXX (PHR) of the system and approval of the PHR committee. If at all practicable, cylinders will be sized to provide a three month gas supply.

In instances when a new gas is introduced to an existing process, temporary approval for use must be received from the chairperson or designee of XXX (CSAC). The temporary approval will undergo a routine review within thirty days.

Compressed Gas Cylinder Safety

Arrangements must be made with authorized staff personnel before handling any compressed gas cylinders. Only trained personnel will handle hazardous gases, unless previous arrangements have been made by the facility manager and/or student's advisor. Cylinder changes of hazardous gases will take place only under the direct supervision of the facility manager or designee.

General

Compressed gases represent a special hazard. Each compressed gas cylinder contains a very large amount of energy. This energy, released improperly, can result in a serious injury. In addition, gas hazards include flammability, toxicity, or corrosiveness. Refer to Material Safety Data Sheets for specific hazards. Hazardous gases must be received at the loading dock only. Hazardous gases must be leak checked, according to the leak check procedure, prior to going into the facility. A phone is located at the loading dock for shippers to notify personnel of their arrival. Cylinders may be placed in Rm XXX for temporary storage.

Precautions

A list of precautions that should be followed to minimize hazards associated with any compressed gas:

1. All gas cylinders, full or empty, shall be handled in the same manner.
2. Do not transport gas cylinders without a valve protection cap in place unless properly mounted for use on a service cart.
3. Do not roll cylinders or use for support.
4. Close valves tightly after use.
5. Do not place cylinders near furnaces or any source of heat. The cylinder temperature should not exceed 125°F.
6. Appropriately secure cylinders so that they can not be knocked over.
7. Do not drop cylinders or handle them roughly.
8. Do not expose gas cylinders to continuous dampness, salt, corrosive chemicals, or fumes.
9. Do not attempt to repair or alter cylinders or valves. If a cylinder is damaged or leaking, inform staff personnel.
10. Never completely empty cylinders.
11. Preserve and comply with all markings and signs applying to compressed gas equipment and systems.
12. No smoking is permitted while compressed gases are being used or handled.
13. Never have oils come in contact with compressed oxygen.
14. Tag cylinders "used". Do not write on cylinder.
15. Do not store cylinders in locations where heavy objects may fall on them.

Gas receiving and transportation

The procedures for receiving new cylinders and returning empty cylinders will be identical. "Empty" cylinders are never entirely empty and must be handled with the same caution as full cylinders.

Transporting non-hazardous gases

1. Cylinder is loaded on freight elevator.
2. Cylinder can be transported down any corridor.
3. Once it is off the elevator, cylinder is transferred to cleanroom cart and wiped down.
4. It is now transported through the cleanroom to the gas room.

5. After the used cylinder has been removed from the system, remove it from the facility in the same manner that the charged one was brought up.

Cryogenic Fluids

General

Cryogenics such as liquid nitrogen and helium are used in cold traps for vacuum systems and process gases. The tools that use cryogenic fluids are the evaporators, Quartz system, and Leak Detector.

Hazards

Explosion, spillage, frostbite, and escape of asphyxiating gases are some of the more common hazards.

Handling

Only authorized personnel will service equipment requiring cryogenic fluids. However, for any exposure or short period of contact with cryogenic fluids, flush area of exposure with large quantities of warm water. Seek medical attention. When pulling off liquid, heavy gloves and face shield should be worn. When filling a large dewar from the holding tank, ear protection should be worn along with a face shield and heavy gloves.

Chemical Safety

Solvents

General: A solvent is any liquid used to dissolve another substance. In microelectronics, solvents are used in many processes, including degreasing, stripping, wafer production, and photolithography. Workers are exposed to solvents mainly by inhalation and skin contact. Each solvent has its own unique properties and health hazards, but some generalizations can be made:

- Solvents can cause acute damage to skin and breathing passages.
- Most solvents enter the blood stream after inhalation; however, some can be absorbed through the skin.
- Most solvents are highly flammable.

- Long term exposure to even low levels can cause a variety of organ damage. Liver, lungs, kidney, and reproductive organs can be damaged from repeated low-dose exposure. In addition, infertility, damage to the unborn, and cancer (caused by exposure to benzene and chlorinated hydrocarbons) can result.
- The exact health effects of long term exposure and the interactions of solvents with other chemicals may not be known at this time. Some solvents thought to be safe (e.g., benzene) are now known to be carcinogens. Therefore, solvents should be treated as potentially harmful. Adequate ventilation, safe storage, and protective garments are among the safety measures that must be used.

Protective attire should be worn when pouring or mixing all solvents and photolithographical chemicals:

- safety glasses/goggles
- face shields
- chemical gloves
- chemical aprons
- closed-toe shoes
- long pants

When photoresist coating wafers, chips, etc., the following can be worn:

- safety glasses
- chemical gloves or PVC gloves
- closed-toe shoes
- long pants

ALWAYS WORK IN A VENTILATED HOOD, NEVER INHALE VAPORS AND NEVER OBSTRUCT PERFORATED EXHAUST HOLES IN HOODS

Acids and bases

Acids and bases (alkaline) are used in a variety of processes in the microelectronics industry.

Acids are used to clean and etch wafers and to clean quartz ware. Bases are used in photolithographical processes and etchant solutions.

All acids can cause injury (burns) when splashed on the skin or in the eyes. Vapors or mists from a solution can not only injure the eyes, but also the mucous membranes and the respiratory system. The extent of the injury depends on the strength and type of acid and length of exposure. Effects on the skin range from mild rashes to sever blisters and ulcers (breaking through the skin). Effects on breathing range from irritation of the breathing passages to chronic bronchitis to pulmonary edema (fluid in the lungs). Long term effects of exposure and interactions with other chemicals are largely unknown.

In the event of skin/eye contact, the exposed area should be flooded with water under an emergency shower or eyewash for 15 minutes. If acid comes in contact with clothing, remove clothing while under shower.

Acids frequently used in the facility are listed in Appendix X with some of their hazards. This list is not a replacement of Material Safety Data Sheets (MSDS). Before working with any chemicals which you are not familiar with, the MSDS should be reviewed. Consult MSDS which are located throughout the facility and in the office, for additional information on any chemicals used in the facility.

Bases can cause injury (burns) when splashed on skin or in eyes. Vapors or mists from the solution can not only injure the eyes, but also the mucous membranes and respiratory system. Due to the permeating nature of alkalis, severe eye injuries can still happen with even a dilute alkali solution.

Effects on the eyes include cataracts and glaucoma. Effects on the skin range from mild rashes to sever blisters and ulcers. Alkali burns are usually more severe than acid burns. Effects on breathing range from irritation of the breathing passages to chronic bronchitis to pulmonary edema.

In the event of any exposure to eyes, rinse with water for 30–60 minutes. In the event of skin contact, the exposed area should be flooded with water under an emergency shower or eyewash for 15 minutes. If bases come in contact with clothing, remove clothing while under shower.

Protective attire will be worn when pouring, mixing, or processing wafers with any acids and/or bases:

- safety glasses/goggles
- face shields
- chemical gloves
- chemical aprons
- closed-toe shoes
- long pants

NOTE: When working in or around acid hoods, always wear chemical gloves. Beware of any objects or controls on the interior or exterior of the hood, as they are likely to have been handled by someone with acid on their gloves.

Oxidizing and reducing substances

General: Oxidation-reduction (redox) reactions can occur in any of the physical states (gas, solid, or liquid). The reactions tend to generate heat and are often explosive. In any reaction of this type, both agents must be present. Usually, one or the other agents creates a hazard when coming into contact with a normally innocuous substance.

Precautionary measures: In general, isolate substance from other potentially reactive compounds. Use adequate protective gear when working with such agents. If the substances involved are not water sensitive, safety showers, sprinkler systems, and flushing hoses should be made available. Refer to MSDS to determine incompatibilities.

Chemical Storage, Handling, Waste Disposal and Hood Operations

Storage

- Never store acids and solvents in the same cabinet or hood. An explosion or fire could occur.
- Only store chemicals in properly designated cabinets or hoods. (IF there is any doubt about the proper location, ASK A SUPERVISOR).
- All containers must be labeled with their contents and owner's name. Otherwise, they will be set aside for disposal and their owner will be suspended from the facility.
- Only chemicals approved by the XXX may be stored in the facility (see Appendix X for approved list).

Handling

- Always know the hazards before handling any chemicals. Read the MSDS.
- Always wear proper protective attire, even when carrying a bottle from the storage cabinet to a hood.
- Using nitrogen guns, leak check gloves for pinhole leaks. Never blow into protective chemical gloves to inflate.
- Always transport chemical bottles in a bottle carrier.
- Verify hood is available and all equipment needed is present prior to bringing chemicals to hood.
- Open chemical bottles only inside hood.
- Wipe acid bottle exterior after pouring. First, use wet lint-free towels and then dry towels. Rinse towels with DI water before disposing in plastic lined trash containers (unrinsed acid contaminated rags present a fire hazard).
- When working for extended periods of time with acids or solvent, rinse gloves periodically and dry with lint-free towels.
- Take great care to avoid touching anything with contaminated gloves or garments. Doing so can leave behind enough material to injure the next person.
- Always rinse gloves and hands with DI water after handling chemicals.
- Hazardous chemicals must be received at the loading dock and transported on the freight elevator only.
- Hazardous chemicals are not allowed down main corridors.
- Excess quantities of chemicals are to be stored in DH XXX.

Waste disposal

Disposal of “empty” bottles:

- Acids – triple rinse interior of empty bottles and rinse exterior in proper acid drains before discarding. Leave caps off after rinse has been completed. These bottles may be placed in regular trash.
- Solvents – “Empty” solvent bottles must be vented under the solvent hood, located in the photolithography area, at least 48 hours before discarding. Mark on bottles with time and date bottle is to be removed and initial. Leave aerated bottle uncapped and discard in regular trash.

Disposal of acids and bases (excluding HF and HF solutions):

- Use aspirator for siphoning acids in acid drains; never use industrial or water drains.
- Rinse acid tanks after aspirating and aspirate empty tanks twice with DI water.
- Clean area around acid tanks after emptying tanks or completing an operation. Use wet-lint free towels and then follow with dry lint-free towels.
- Rinse towels thoroughly with water before discarding in a plastic bag lined trash can.

Disposal of HF and HF solutions:

- The acid neutralization system is not designed to be used with HF.
- Use rinsed out plastic chemical bottle for HF waste.
- Mark out old label and clearly mark contents of bottle, initial, and date.
- HF etches glass. **DO NOT USE GLASS BOTTLES!**
- Acid waste pick-up is scheduled by campus Hazardous Materials (5-6863).

Disposal of solvents:

- Aerated solvent bottles are used as waste containers for solvents.
- Waste bottles should be clearly marked for appropriate waste to be collected.
- Waste developer solution should be stored in a waste container designated for waste developer.
- Solvent waste pick-up is scheduled by campus Hazardous Materials (5-6863).

Chemical spills inside hoods

CAUTION: All chemical spills present an immediate safety hazard. Clean-up immediately with trained personal.

Inside hoods

Solvents:

- Eliminate any source of ignition or sparks (such as a hotplate).
- Use adequate amounts of lint-free towels to wipe up spilled solvents.
- Discard towels in a plastic bag. Tie bag and label for disposal.

Acids:

- Aspirate from work surface.
- Spray with DI water.
- Aspirate the DI water.
- Repeat preceding two steps.
- Dry area with lint-free towels.
- Rinse and dispose of towels in a plastic lined trash container.

Chemical hood operation

Acid and solvent hoods are considered process equipment or tools. The facility protocol and general rules must be followed for any chemical hood operations.

- 1) Proper protective attire must be worn (see Chemical Safety section).
- 2) Only specific approved chemicals may be used for approved operations conducted in a particular hood.
- 3) Never touch the interior or exterior of chemical hoods with bare hands due to the possibility of chemical residuals.
- 4) Do not touch anything outside of chemical hoods with chemical gloves. Hood controls may be touched after rinsing and drying gloves.

Last updated 5/6/2005

Send feedback to stufer@ncsu.edu or gmwalker@ncsu.edu

- 5) Never submerge gloves in acids or solvents (pinholes are sometimes present). Gloves can be checked by using nitrogen guns to inflate glove and inspect for holes.
- 6) Blower should always be left on. Hood certification is valid only with blower on.
- 7) Hood sash should not be used above 11" for optimum hood performance.
- 8) Light should be on while hood is in use.
- 9) **DO NOT USE SOLVENTS IN ACID HOODS OR ACIDS IN SOLVENT HOODS.**
Explosion might occur. Exception: Ethylene Glycol or Triton X-100 (detergent).
- 10) Lights should be off when hood is not in use.
- 11) Ensure DI water, acid siphon, and heated baths are off when work is complete.
- 12) Carefully remove protective clothing and put in appropriate place.

NOTE: Be familiar with the hazards, toxicity, and flammability of all gases used in this cleanroom. Most of these gases can present a life-threatening hazard.