

Nanofabrication Center (NFC)

SAFETY MANUAL AND EMERGENCY RESPONSE PROCEDURES

UNIVERSITY OF MINNESOTA

1-165 ELECTRICAL ENGINEERING/COMPUTER SCIENCE BLDG.
(612) 624-8005
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The safety rules and emergency response procedures for use of NFC facilities must be read, understood, and practiced at all times. Use common sense when thinking of safety. Think of how your actions will affect other lab users as well as yourself.

The rules outlined in this course have evolved from experience and exist to protect you and your fellow researchers. Failure to follow them will result in expulsion from the lab. If you have any questions, feel free to ask a staff member. Remember, there is no excuse for not following these safety procedures.

In addition to this safety manual, users should also be familiar with the Laboratory Safety Plan for the Nanofabrication Center. The LSP contains more complete information regarding University of Minnesota safety requirements. This safety manual, which forms an appendix in the LSP, contains information and procedures specific to the Nanofabrication Center.

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1. GENERAL

1.1 Buddy System

NEVER WORK ALONE. This rule is absolute. Find out if others are working in the lab. Locate one of them and tell him/her where you will be working. You should check up on each other frequently, at least every 30 minutes. If no one else is present you may not work until you can find another lab user. It is a good idea to plan ahead if you want to work in the evening or on a weekend. No one is **EVER** permitted to work alone.

1.2 Handling Emergencies After Hours

If an emergency arises on weekends or after hours when staff is not immediately available, call 911 in the event of a serious emergency, and (for example a fire or an accident requiring first aid) notify a staff member and the University Building System Automation Center (BSAC):

Gregory Cibuzar	625-8079 (W)	651-452-7472 (H)
Mike King	625-0747 (W)	763-421-3836 (H)
Mark Fisher	626-7465 (W)	952-882-1271 (H)
Rich Macy	626-7472 (W)	763-753-0876 (H)
Terry Brough	626-1871 (W)	651-407-6405 (H)
Tony Whipple	626-1868 (W)	952-461-2930 (H)
Kevin Roberts	624-7092 (W)	(H)

Building Systems Automation Center (BSAC): 625-0011

Environmental Health and Safety: 626-6002

Medical Emergency:

Emergency Medical 911

Police: 624-COPS

The nature of the emergency will determine whether you will call police, staff, or both. If there is no response and matters are serious, dial 911. If someone is injured, the police and an ambulance should be called before calling staff. If there is a facilities problem that does not represent danger to others, but may result in damage to equipment, i.e., a flood, only staff and BSAC need be called. University Police should always be called when a potentially life threatening situation exists (gas leak, suspected bomb, etc.).

1.3 Safety Awareness

Please report any safety problems you encounter to a staff member. Your input and observations will be appreciated.

1.4 Restrictions

No open shoes, sandals, or shorts are permitted. We discourage the use of contact lenses in the laboratory due to the hazard of trapping dissolved chemicals in or under your lenses. If you still choose to wear contact lenses, we strongly suggest you to wear "chemical splash goggles" at all times when in the laboratory. All laboratory users must wear protective eye wear at all times when in the cleanroom.

2. ALARMS AND EVACUATION

As part of the laboratory safety systems, a toxic gas monitoring system constantly checks the air in various parts of the lab. If this system determines that a leak into an occupiable area has occurred, and the resulting concentration of toxic gas is above the OSHA defined safety levels, the fire alarm will sound inside the lab. In addition, if the combustible gas monitoring system determines that a certain amount of oxygen or hydrogen has been released from the house distribution system, the fire alarm will also sound. The fire alarm could also sound due to a fire in the lab or in another part of the building. Regardless of the cause of the alarm, a lab occupant should be concerned with only one thing-exiting the facility calmly in the most direct way. Know the evacuation routes from all parts of the laboratory. Exit immediately upon hearing the alarm, don't wait to make that last notebook entry. If you are in the process of a procedure (such as pouring a chemical), finish the task as quickly as possible (cap the bottle) and exit. **DO NOT RUN.**

A second type of alarm which can occur in the laboratory is an intermittent bell-like sound. This alarm indicates that the toxic gas monitoring system needs maintenance. Normally this does not require evacuation of the lab as all toxic gases are automatically shut off in this situation.

3. CHEMICALS

3.1 Chemical Information and Reference Materials

A large variety of chemical information exists in the staff office (including the following two books) and users should familiarize themselves with them.

"The Merck Index"

"Toxic Gases - First Aid Medical Treatment"

Materials Safety Data Sheets (MSDS) are available in the staff office and at the entrance to bay 2 in the cleanroom. These supply all chemical specifications and some safety information. If you need additional information, call the NFC office at 624-8005.

If you have any questions regarding a given chemical, consult these sources BEFORE using it. Handling chemicals requires common sense.

3.2 Protecting Yourself

Before you start working with chemicals, make sure you are properly protected. Working with acids and other corrosive chemicals means you must wear rubber gloves **AND** safety goggles. If you will be working with large volumes of corrosive or caustic, wear a blue chemical splash apron as well. Always work with chemicals in exhausted wet benches in the laboratory, and if possible keep the chemicals in containers which fit down into the wet bench openings (this maximizes the exhaust capabilities).

Remember that the cleanroom gloves you put on when you enter the lab are to prevent particulate contamination, and are **NOT** sufficient to protect against chemical burns. They are also soluble in some solvents. Use the chemical gloves provided at the wet bench for handling chemicals (put these chemical gloves on over your cleanroom gloves). If gloves, aprons, or face shields aren't readily available near the wet bench, contact the office and the necessary items will be provided to you.

Two types of gloves are commonly used in the lab:

a) Latex gloves (yellow)

These prevent you from contaminating your wafers, or anything that comes in contact with wafers, such as teflon cassettes.

b) Rubber Gloves (orange)

If there are none, you can obtain them from the staff office. These must be worn whenever you work with caustics or corrosives.

If immersion or exposure of your gloved hands in caustic or corrosive material is anticipated, it is a good idea to leak-check your rubber gloves. This is accomplished by pressurizing them with a nitrogen gun, then immersing them in water. Check for bubbles, a sure sign of a leak. After using the gloves thoroughly rinse the outside surfaces and discard them if they appear damaged or leak. Otherwise, dry them and store them near the wet bench.

3.3 Transporting Chemicals Through the Lab

No glass chemical bottles are to be transported through the lab by hand. All chemicals are to be moved using either a cart or individual polypropylene bottle carriers. The acid cart with plastic bins, located in cleanroom hallway, is available if you need to move more than 2 bottles through the lab at any given time. Individual bottle carriers are available near the chemical storage cabinets. Please return these carriers and the cart when you have finished with them.

Please be sure to check that there are no bottles of the chemical you need in your area before bringing in and opening new ones.

3.4 Handling Chemicals

When measuring out chemicals, **NEVER POUR A CHEMICAL BACK INTO ITS REAGENT BOTTLE.** This can contaminate the chemical and damage the next user's devices. When removing dry chemicals, pour them out if possible. Scoop only when necessary and use freshly cleaned spatulas.

If you pour out way too much, instead of throwing it away, you might want to store it in a clean, labeled container for your later use.

3.5 Chemical Burns

If you are exposed to chemicals, immediately remove affected clothing and flush the area with large volumes of water for 15 minutes; **NOT LESS.** Use the emergency shower and/or eye washes if necessary. Hands can be rinsed in a wet bench using either the faucet or the DI water spray gun. Know where they are located. Contact a staff member as soon as possible. After flushing, seek medical attention, as damage may not occur for several hours, and it is a good precaution.

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 result in massive tissue damage. If you contact HF, flush the area well and be sure to scrub under and around your finger nails. This is the classic area where people receive burns, having washed off the HF and not realizing it went under their nails. If washed off within a few minutes of exposure, HF will do no harm. Remember, it doesn't produce any burning sensation until after it has already done damage. Any HF burns or other serious acid burns should be looked at by a physician. "Acid Aid" for HF burns can be found on the chemical spill cart in Chase 1, as well as near the chemical storage cabinets containing HF.

3.6 First Aid

Injuries such as minor burns and cuts can be treated with first aid supplies located in the metal cabinet in the gowning room.

3.7 Chemical Spills

In the event of chemical spills you should be aware of the Chemical Spill Cart located in Chase 1, between Bay 1 and Bay 2. This cart contains several chemical absorbing materials. The Spill Pillows are used to absorb and neutralize chemicals. They are contained in absorbent bags and designed so as to minimize interference with our clean rooms. The vermiculite is very absorbent and used on solvent spills to prevent fires. The Spill Pillows should be disposed of by placing in plastic bags (also available in the front of the lab) and contacting a staff member. Personal protective equipment is also stored on the cart for your convenience.

3.8 Mixing Chemicals

When mixing acids with water, remember to **ADD ACID TO WATER** and **NEVER WATER TO ACID!** Use appropriate containers. Never put HF in a glass container. Always place fuming containers down inside the wet benches. If you must leave an area where you have a process in progress, make sure you leave your process clearly labeled with your name, date, time, your expected time of return, and chemicals involved. Please do not leave chemical processes unattended unless absolutely necessary.

3.9 Chemical Disposal

When you are through with a process, clean up completely. Dispose of your solutions properly as follows:

NO CHEMICALS ARE TO BE DISPOSED OF BY WASHING DOWN THE DRAIN. Waste disposal containers exist for all the chemicals which we stock in the lab. After finishing with your process, dispose of the waste in the appropriately marked container. If this container is not available or is full, obtain an empty container and affix a properly filled out hazardous waste label before storing the container in the appropriate chemical storage cabinet. If the container is full, place it in the chemical cart in the main hallway.

4. COMPRESSED GASES

4.1 Handling Gas Cylinders

Cylinders of both toxic and non-toxic compressed gases are used throughout the lab. No one is allowed to install or disconnect these bottles except a staff member. There are several reasons. The gases in these can be at pressures as high as 3000 psi. That makes a cylinder as powerful as a rocket. Regulators are designed to handle specific gases and can explode if not chosen properly. Some gases, such as phosphine and arsine, are extremely toxic. Improper installation and purging will contaminate a full bottle of gas. Some of our etching gases cost thousands of dollars and their loss or contamination is very costly.

All gas cylinders must be chained or strapped down.

4.2 Toxic Gases

Many toxic gases such as arsine, silane, ammonia, and phosphine are used in the laboratory. These are extremely toxic gases with characteristic odors. Phosphine smells like decaying fish, while ammonia has a pungent, acrid odor. Arsine is also very toxic (the toxic threshold level is 50 parts per billion). Silane, a pyrophoric gas (i.e., it explodes upon contact with air) is found throughout the lab. Hydrogen is used in the lab by the Thermco furnaces. Its explosive quality is well known. The lab must be evacuated should a leak even be suspected. If you notice any unusual odors, leave the lab and report it to the staff immediately. The toxic and combustible gas monitoring systems are designed to detect leaks and initiate appropriate evacuation procedures.

If you notice an unusual odor and suspect a gas leak when staff are not immediately available, such as on a weekend or after hours, leave the lab immediately and take everyone else with you. Call a staff member at home and ask for instructions.

4.3 Nitrogen Guns

Nitrogen guns and compressed air, if not used properly, can inflate the skin like a balloon, tearing it away from the tissue underneath. Be cautious to avoid cuts when spraying nitrogen or working around air streams.

5. CYROGENIC HAZARDS

Liquid nitrogen or "LN2" is used commonly in the lab. Its major hazards are burns from freezing and damage to the lab floor from cracking. Never put LN2 in a closed (unvented) container. Containers not specifically designed for transportation of LN2 are prohibited.

6. FIRE HAZARDS

6.1 Fire Prevention

Fires in the lab can result from the ignition of flammable gases, or solvents, and combustion of materials. A major cause of lab fires is ignition of chemical solutions on hot plates. Always use a water bath to heat flammable organics. Avoid water around electrical appliances.

6.2 In Case of Fire

In the event of a fire, pull the nearest fire alarm. Evacuate the laboratory and the building immediately. Occupants of the laboratory are not obliged to fight fires.

If you ignite your clothes, use the showers immediately and don't panic. There are also fire suppression blankets in each of the bays near the entrance. **MAKE SURE YOU ARE AWARE OF THE LOCATION OF THE SHOWERS AND EYE WASH STATIONS.**

6.3 Sprinkler System

The lab is covered by a water type sprinkler system. Although this type of system is highly reliable, it is possible a sprinkler head could be broken. This system is designed to deliver 15 gallons/minute. When water flows, an alarm is automatically sent to the fire station and firemen will respond.

7. ELECTRICAL SAFETY

All electrical wiring is to be done by staff/physical plant personnel only. Know the locations of the circuit breakers and electrical disconnects required by the equipment you will use. In case of electrocution of someone in the lab, **DO NOT GRAB THEM.** Disable the power immediately by closing the appropriate circuit breaker or disconnect. Do not overload circuits. Report all problems to the staff.

8. SUMMARY OF LABORATORY PROCEDURES

To protect the interest of all users and the laboratory, a summary of the many do's and don'ts is listed here.

DO:

- Sign into the lab by using your access card.
- Work only when others are in the lab and check up on each other often.
- Follow proper gowning procedures.
- Know the location of the phones.
- Know the location of the eye washes and showers..
- Minimize entry into areas you don't require, such as the chases.
- Training is required on any equipment used. Become a qualified user by taking a shortcourse!
- Report all equipment problems to staff.
- Wear appropriate safety items when handling chemicals.
- Put on rubber gloves and safety goggles when handling chemicals. Rinse gloves when through.
- Use the chemical cart or bottle carriers to move chemicals through the lab.
- Place fuming chemicals inside the wet bench openings.
- Label any ongoing chemical process.
- Let staff know of safety problems.
- Always return tools and lab accessories to their proper locations.

- Wear your ID badge at all times in the lab.
- Wear vinyl gloves at all times in the lab.
- Sign in to all required log books and billing books.

DON'T:

- Eat or drink in the lab.
- Wear sandals, open shoes or shorts.
- Bring visitors into the lab for tours without permission.
- Enter the lab unless you belong there.
- Bring ordinary paper or cardboard into the lab.
- Handle things ungloved.
- Play with equipment or knobs.
- Use equipment for which you are not properly trained.
- Work on equipment or modify it without talking first to the Lab Manager or a staff member.
- Use other people's supplies.
- Mix solvents and acids at any time.
- Move a chemical bottle without a cart or carrier.
- Hook up or change gas cylinders.
- Spill liquid nitrogen on the floor.

These do's and don'ts are a reminder for you. The bottom line here is to provide the best research environment possible for you and other users of the lab. Please respect it and each other.

9. LAB ETIQUETTE

Mutual consideration of your fellow researchers is essential to the efficient operation of the lab. It will also make life a lot more pleasant for all involved. Please think about how you would like others to deal with you when you are working in a space that is shared by so many.

1. Leave your work area the way you would like to see it when you come in:
 - a. No unlabeled containers with chemicals on work areas.
 - b. No unlabeled beakers cluttering up the drying area.
 - c. No unreported equipment problems.
 - d. No used gloves lying around.
 - e. A clean photoresist spinner.
 - f. No empty bottles lying around.

2. Be considerate of your fellow lab users:
 - a. Share sink space cleanly and safely.
 - b. If you reserve equipment, show up. If you cannot show up, cancel your reservation.

3. Consider the general welfare of the lab:
 - a. Remember, you have a stake in its operating smoothly. The lab staff is here to **HELP**, not to serve you. Students should clean, etc., when they know how to do so. When you do need staff help, assist them, and learn from them.
 - b. If an equipment alarm goes off, try and find out why. Know what the alarms mean in your work area. See if there is anything you can do. Notify someone. Don't just turn it off!
 - c. When you have the slightest doubt about anything, **ASK!!** Staff would rather answer questions than fix broken equipment. Use other students as a resource!
 - d. Pay particular attention to sources of particulate and chemical contamination.

10. DISCIPLINE

The above write-up is intended to provide information and guidelines necessary to keep the lab running smoothly. Many of these guidelines are simply common sense and require consideration of the other laboratory users. Others require specific knowledge of either proper equipment use or of chemical handling and safety. It is ***YOUR*** responsibility and obligation to be trained in on a particular piece of equipment or to be aware of correct chemical handling procedures. If you do not have these skills, learn them from lab staff before performing the task.

The guidelines are subject to revision dependent upon laboratory procedural changes. Be aware of new or changing lab guidelines.

Please encourage proper lab usage among the other lab users and report any serious violations of the guidelines to lab staff.

The following procedure will be used to discipline offenders in the laboratory. For each offense by a particular individual which is deemed unique by the safety officer, the following three step system will be used:

First Offense: The individual would meet with the safety officer. If the offense was a rule the individual was unaware of, a warning would be given. If the offense was more severe, a memo would be sent to the advisor. This determination would be made by the safety officer and the offender.

Second Offense: The individual would meet with safety officer, lab manager, and advisor. The corrective action would then be decided by this group. This action may include suspension of lab use.

Third Offense: Expulsion from the laboratory.

II. NFC CHEMICAL SPILL EMERGENCY RESPONSE PLAN

I. Policy Statement

All NFC employees and laboratory users are responsible for cleaning up their own spills. You may be given directions on how to do this on your own or, if the situation warrants, directly assist in cleaning up the spill.

II. Purpose

The purpose is to outline spill response procedures that minimize the risk of injury to occupants of NFC.

III. Procedures

- A. Evacuate personnel from spill area.
 1. Alert neighbors.
 2. Close doors
 3. Isolate area.

- B. Attend to victims.
 1. Remove person from spill area to fresh air.
 2. Immediately remove contaminated clothing.
 3. Wash skin with soap and water.

4. Flush skin with water for at least fifteen minutes. (You may not feel any effect from base spills, but it is still important to wash immediately and thoroughly.)
 5. If chemicals spilled on body over a large area:
 - Remove contaminated clothing while under shower.
 - Flood affected body area in cold water for at least fifteen minutes.
 - Resume water wash if pain returns.
 - Wash off chemicals with mild detergent and water; do not use neutralizing chemicals, unguents, creams, lotions, or salves. (Special precautions for HF).
 6. Be sure medical personnel understand exactly what chemicals are involved.
- C. Remove ignition sources.
1. Turn off hot plates, stirring motors, flame sources.
 2. Shut down all equipment.
- D. Evaluate whether help is needed.
1. Notify the NFC Laboratory Staff, Manager, and/or Director. (Phone numbers are listed in the Laboratory Rules for after hours emergencies.)
 2. General guidelines to follow:
 - A) less than one gallon.....handle it yourself, with the assistance of NFC Staff.
 - B) more than one gallon.....call Environmental Health and Safety (626-6002).
 - C) very toxic or poses a fire hazard.....call Environmental Health and Safety (626-6002).
- E. Locate the spill kit in the NFC clean room in chase 1.
- F. Choose appropriate personal protection.
1. Always wear protective gloves and goggles or face shield.
 2. If there is a chance of body contact, wear apron and coveralls.
 3. If spill is on floor, wear boots.
 4. If there are inhalation hazards, wear a respirator.
- G. Confine or contain spill.
1. Small amounts of inorganic acids/bases:
 - Use neutralizing agent and absorbent material.
 2. Small amounts of other materials:
 - Absorb with non-reactive material (e.g. vermiculite, sand, towels, Floor-Dri)
 3. Large amounts of inorganic acids/bases:
 - Neutralize and call for help.
 4. Large amounts of other materials:
 - Make a judgment call: depending on the amount, toxicity, or what the substance can run into or react with, you may handle it yourself or call for help.
- H. Spills that require special handling:
1. Acid chlorides:
 - Use Oil-Dri, Zorb-All, or dry sand.
 - Avoid water, avoid sodium bicarbonate.
 2. Mercury:
 - Use aspirator bulb or suction device (available from Edmond Scientific and Markson Scientific).
 - Mop with mercury decontaminating powder.
 - Don't use vacuum cleaners.
 - Call Department of Environmental Health and Safety and ask for mercury-vapor monitoring instrument.
 3. Alkali metal:
 - Smother with dry sand.
 - Put in hood.

- If possible, dispose of by reaction with isopropyl alcohol.
4. White (yellow) phosphorus:
 - Blanket with wet sand or wet absorbent.
- I. Remove absorbent material with a broom and dust pan.
 1. Place in plastic bag or other appropriate container.
 2. If spilled chemical is a volatile solvent, transfer plastic bag to a fume hood for evaporation of solvent.
 3. After evaporation, discard with other non-hazardous solid waste.
 4. If spilled substance is non-volatile, hazardous chemical, dispose as a hazardous chemical waste.
 5. If spilled substance is non-volatile, non-hazardous chemical, dispose as normal trash.
 - J. Wet mop spill area.
 - K. SPECIAL TREATMENT
 - Treat victims of HF spills:
 - Flush with cool water until any whitening of tissue disappears.
 - Treat affected area with Acid Aid HF neutralizing cream available near HF storage cabinets.
 - Swath injured area with soaking wet, iced cloths.
 - Get immediate medical help.

III. EMERGENCY RESPONSE FOR THE NFC LABORATORY

This document determines the Emergency Response to be initiated in the event of the four alarm conditions of the Laboratory. These alarm conditions are:

1. Smoke Detector Alarm
2. Combustible Gas Sensor Alarm
3. Toxic Gas Monitor Alarm
4. Ventilation Failure Alarm

The items 2-4 above are "Warning" conditions with a Laboratory wide alarm consisting of sounding of the fire alarm. The smoke detector alarm (item 1) will be responded to by the Fire Department. A combination of (2) and (4) or (3) and (4) will cause the building fire alarm to be activated and result in building evacuation and response from the Fire Department.

1. A local NFC Laboratory alarm, identified by the sounding of the fire alarm in the Laboratory, means the Laboratory should be evacuated immediately. If the building fire alarm is also sounding, then the building should also be evacuated. Go to the nearest stairwell and proceed up to the third floor emergency exit.
2. If an occupant, who is incapacitated, can be helped to evacuate the area, help should be given and this person should also evacuate the area and/or the building as required. The incapacitated should obtain immediate medical emergency help through the 911 response.

3. It is not the responsibility of the NFC Laboratory occupants or the NFC staff to fight fires.