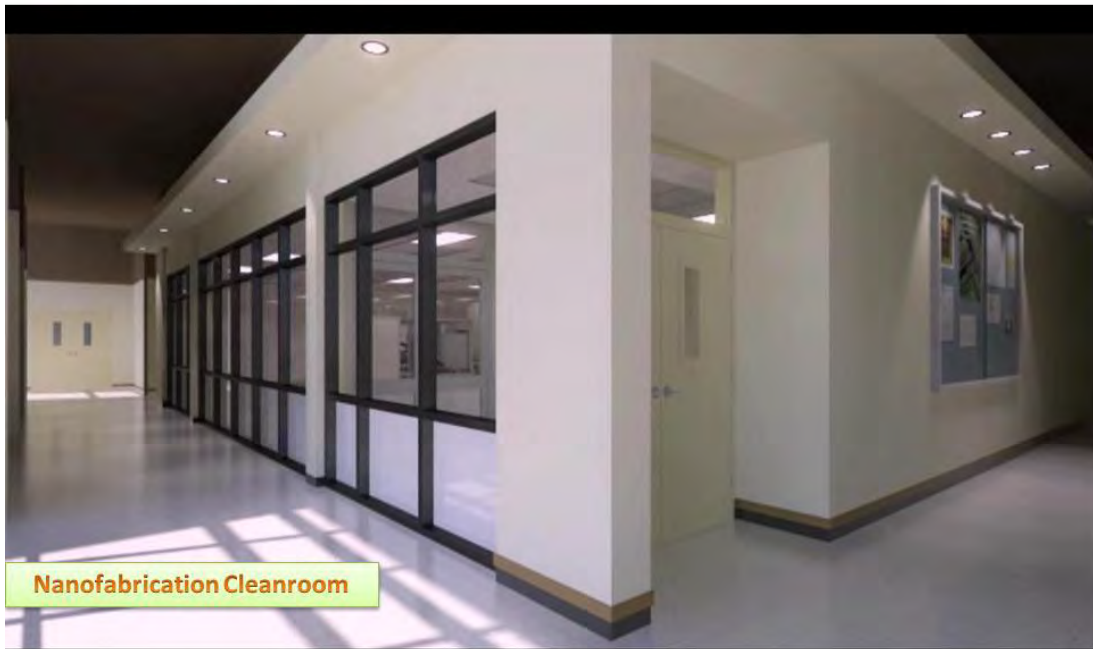


GENERAL CLEANROOM SAFETY AND PROCEDURES MANUAL

Material Research Facility-Nanofabrication Cleanroom, University North Texas, Update: 04/10/2020



EMERGENCY CONTACTS

Primary Emergency Contact: 911
Poison Control Center: 800-222-1222

For Non-Emergency Chemical Situations:
Department of Risk Management
(DRM): 940-565-2123
UNT Police: 940-565-3000

If Time Permits, Contact the Cleanroom Staff:
Dr. Jianchao (J.C.) Li: 940-369-5318

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1) Cleanroom Configuration & Operational Responsibility

The UNT cleanroom is a contiguous space of about 2,800 square feet containing semiconductor processing, and measurement systems. There are 3 gas storage room containing 4 gas cabinets. The gas storage rooms are fire rated, and have sprinklers, toxic gas detection, and its own exhaust ventilation system. The gas storage rooms are a locked, controlled access space that may not be entered without approval.

Activation of the fire alarm system (horns and strobes) requires immediate evacuation of the building.

The toxic and pyrophoric gas monitoring system in the cleanrooms is a Honeywell Midas system which is a continuous monitoring system. Sampling points are located where hazardous gases are used. Throughout the cleanrooms, there are light/horn which relate to this system, as described in the chart located in Appendix II. Emergency- gas-off buttons locate at the entrance of the cleanroom and chase area. They will shut down the toxic gases. Located in workroom is the main computer for this system.

This system is designed to shutdown gas flows if unsafe levels are detected; **the gas monitor system is tied into the building fire alarm system which would only activate if there is a hazardous gas.**

The gas cabinets contain up to two process gases with an independent nitrogen purge system for both purity and safety considerations. All gas cabinets have self-closing with latching doors and a sprinkler (flammable gases ones). Each cabinet is vented so that there is a minimum of 200 fpm across the cabinet window when it is open.

Cylinder changes may only be performed by trained and authorized personnel. **Access to the gas storage rooms is limited to authorized personnel only.**

The high purity gas lines for the corrosive, toxic and pyrophoric gases have a concentric, coaxial structure and have been helically welded to form one continuous piece from the cabinet to the equipment. The process gas flows through the central core and the outer sheath is purged with nitrogen back to the gas cabinet. The outer jacket pressure gauge has both an audible and visual output at the process tool to indicate a drop in pressure. The pressure sensor is tied to the fire alarm system. In case of pressure change, the cleanroom will be evacuated. **No process toxic gas piping may be installed or modified without prior approval of the Cleanroom Advisory Committee.**

The Cleanroom Advisory Committee (CAC)

The Cleanroom Advisory Committee has the responsibility to resolve issues concerned with the use of shared facility. The CAC has the following responsibilities:

- Coordinates standardization of safety protocols
- Identifies particularly hazardous materials or processes that require a safety review
- Coordinates safety and Process Hazard Reviews (PHR) with the UNT risk management department. A PHR is intended to assure that single point failures of laboratory research equipment does not cascade resulting in catastrophic system failures. This is required for new or modified equipment. The PHR identifies hazardous materials or laboratory procedures and recommends mechanisms by which hazards can be minimized.
- Coordinates implementation of training programs for cleanroom users. Helps assure there is an emergency response training with Risk Management, Public Safety, and Denton emergency response agencies.

2) General Facility Rules & Tool Procedures[1]

Access to the cleanroom facility is restricted to those personnel who have completed the necessary training and received authorization for cleanroom access. Principal Investigators are responsible for determining who has access. Personnel that have not received training must be escorted within the cleanroom at all times, by trained personnel.

Cleanroom Facility Rules [1]

1) Enter cleanroom wearing proper attire (Clean room attire protects the environment from contamination generated by people. Personal Protective Equipment (PPE) is required for specific chemical hazards as defined here in.)

- safety glasses (contact lens wearers must wear goggles in areas where there is a risk of chemical/gas exposure.)
- closed-toe, preferably non-cloth, non-skid shoes (spiked high heels (>2" high) are not allowed)
- clean long pants
- cleanroom gloves
- cleanroom jumpsuits
- boots or shoe covers
- hair net

Visitors may use Tyvek garments.

- 2) Log in/out when entering/leaving the facility.
 - 3) No smoking, eating or drinking (this includes chewing gum) in change room or facility is allowed.
 - 4) Know and follow regulations listed in Cleanroom Facility Protocol.
 - 5) There must be at least two people within hearing range while working in the facility.
 - 6) Never touch or operate equipment unless you are an approved user.
 - 7) Always report injuries promptly.
 - 8) Always be alert to what is going on around you.
 - 9) Never hesitate to admit you have made a mistake. This can prevent equipment damage or personnel injuries.
 - 10) Participate in lab clean-ups.
 - 11) After hours work will be determined by Lab Manager / Principle Investigator.
 - 12) Use appropriate PPE when handling hazardous materials.
 - 13) Contact Campus Police Department ((940) 565-3000) in case of:
 - Fire
 - Any exposure to hazardous chemicals or gases
 - Injuries that require immediate medical attention
 - Major chemical spills
 - Facility evacuation
- Any violation of facility rules could lead to loss of privileges.

Cleanroom Facility Protocol

Along with safety, particle control is a fundamental part of the cleanroom environment. The cleanroom is a combination of class 100 and class 10,000 cleanroom space. To maintain cleanliness all garments will conform to a class 100 requirements. Particle counter is used for routine cleanliness check throughout the whole area in the cleanroom.

Entering cleanrooms: The cleanroom supervisor will register your student after successful completion of the safety orientation and test. Do not use your card open door for other users.

Gowning Procedure: Put on hair net first, then the coveralls. The boots/shoe covers are put after coveralls. Put on latex or Nitrile gloves last. To disrobe, remove boots/shoe covers, coveralls, and hair net. When removing coveralls, do not allow arms to touch the floor. Place on hangers for reuse or dispose if tears are found.

Guidelines to maintain cleanroom environment:

- Tacky mats have been strategically located around entrances to minimize the amounts of particles carried into cleanroom space via shoes. Do not bypass these mats.
- Cleanroom paper is the only paper allowed in this facility. Spiral and 3-ring notebooks of cleanroom paper are available through various vendors, such as Fisher Scientific.
- To maintain a cleanroom environment, while working in the facility no cosmetics or hair spray may be worn. Perfumes or colognes should not be applied prior to entering facility. Drink a cup of water, or wait at least fifteen minutes before entering the facility after smoking tobacco products.
- DO NOT enter change room with dirty shoes.
- Cleanroom gloves must be worn at all times in the clean room. If a glove's exterior comes in contact with skin or a dirty, oily surface, the glove must be changed. If a glove rips or gets punctured, it must be changed.

- Wafer Handling: While inspecting a wafer, the other wafers must remain in the wafer box with lid in place, but not necessarily closed tight. Wafers must be covered when chase doors are open. Do not lean over the wafers when inspecting them. Never touch a wafer with a glove, not even the edge.

NEVER

- Comb hair in the smock room.
- Bring food or drink into the cleanroom.
- Chew gum or tobacco in the cleanroom.
- Run or walk fast in the cleanroom under normal circumstances.

THESE ITEMS ARE NEVER ALLOWED IN FACILITY class 100 area:

- Ball-point click type pens
- Felt tip pens
- Pencils
- Liquid paper
- Notebooks constructed of regular paper.
- Cardboard or wood products

Equipment Usage Procedure:

Only approved individuals whose name appears on each equipment list may operate that particular tool. All work must be approved prior to use of equipment and directed by staff personnel.

- Each tool requiring training will have an approved users list for that tool. No others may use these tools.
- In the event of queuing, sign-ups are needed to establish order of use. Please pay attention to sign ups. Many tools have a lot of usage and signing up for blocks of time is the only fair way to establish queuing. If you have signed up and find that you are unable to keep that time, remove your name as soon as possible to allow others to sign up.
- Tool settings must not be changed without permission of the facility manager or their designee.
- Fill in all required log sheets with all pertinent information.

Bringing Items, Tools & Equipment into the Facility

- Items that are cleanroom packaged may go through the smock room. Remove outer layer of material in smock room.
- Item can be brought into facility through the smock room. Gown up and enter cleanroom. At this point, wipe down all exposed surfaces with Isopropyl / DI water solution.

New Process Equipment

New process equipment must be approved by the Cleanroom Advisory Committee before the equipment is ordered or donated. Once approval has been received, then you must work closely with Risk Management to address all requirements of a tool before it arrives and eliminate problems that could occur after the equipment is received. All new equipment must have a Process Hazard Review prior to being brought into facility. The purpose of this is to establish that all the requirements to bring a tool safely into the cleanroom are available and in place before the tool arrives.

Lockout / Tagout

The purpose of lockout / tagout is to ensure that machines or equipment are isolated from all potentially hazardous energy, and locked out or tagged out before employees perform any servicing or maintenance. This is done to prevent unexpected energization, start-up or release of stored energy that will cause an injury.

Do not attempt to operate any switch, valve, or other energy isolating device when it is locked or tagged out. Use a tagout system only if an isolating device cannot be locked out or there is demonstration that a tagout system provides full employee protection.

Lockout / Tagout Procedure

1. Notify all affected employees that a lockout or tagout system is going to be used. The authorized employee shall know the type and magnitude of energy that the machine or equipment uses and shall understand its hazards

2. If the machine or equipment is operating, shut it down by the normal stopping procedure (depress stop button, open toggle switch, etc.).
3. Operate the switch, valve, or other energy isolating device(s) to isolate the equipment from its energy source(s). Dissipate, deactivate or restrain stored energy (such as that in springs, elevated machine members, rotating flywheels, hydraulic systems, and air, gas, steam, or water pressure, etc.) by methods such as repositioning, blocking, bleeding down, etc.
4. Lockout or tagout the energy isolating devices with assigned individual lock(s) or tag(s). Use the method(s) selected;
i.e., locks, tags and additional safety measure, etc.
5. To ensure personnel protection, and to check on the disconnection of the energy sources. Operate the push button or other normal operating controls to make certain the equipment will not operate. Caution: Return operating control(s) to "neutral" or "off" position after the test.
6. The equipment is now locked out or tagged out.

Restoring Machines or Equipment to Normal Production Operations

1. After completing the service or maintenance and determining that the equipment is ready for normal production operations, check the area around the machines or equipment to ensure that everyone is clear.
2. After removing all tools from the machine and reinstalling equipment guards and determining that all employees are in the clear, remove all lockout or tagout devices. Operate the energy isolating devices to restore energy to the machine or equipment.

3) Emergency Response

The University has established an emergency response protocol to address and handle emergencies occurring on, or adjacent to University property. All emergency conditions should be promptly reported by calling **(940) 565-3000**. This chapter reviews the Emergency Response Plan for the cleanroom and provides details relevant to the cleanroom facilities.

Facility Evacuation

Evacuate the facility when:

- Power failure occurs
- Hazardous Gas Alert in Gas Cabinet or in Tool (red light)
- Exhaust failure (amber light)
- Fire alarm sounds (red light and piercing)
- Major Chemical spill occurs (amber light)

Evacuation Procedures

- Shut off heated baths or hot plates.
- Leave the facility as quickly as possible through nearest exit. Emergency exits are shown on the facility layout (Appendix I)
- Make certain that no one is left in the facility by visually surveying your work area.
- Leave your clean room attire on. **DO NOT TAKE TIME TO UNDRRESS OR LOGOUT!**
- After exiting, meet at designated area for your cleanroom.

NOTE: Most process tools are equipped with alarms that do not warrant facility evacuation. However, always investigate tool alarms, even if you are not working on the tool. When possible, isolate a system in a "safe" condition.

Overview of Fire Protection Systems

The cleanroom is a fully sprinkled, fire resistive building. The fire alarm system for the building consists of pull stations, and sprinklers. The cleanroom gas monitoring system is connected to the building fire alarm system.

In event of an alarm, alert tones are issued through combination horn/strobes. Simultaneously, the alarm is transmitted UNT police department. The UNT police Officer has written procedures in place for notification and response to alarms. Denton fire department responds to all fire alarms. Any activation of the fire alarm horns and strobes requires immediate building evacuation. Do not re-enter the building unless authorized by appropriate personnel.

The Solvent wet bench has on board CO₂ fire suppression system. When smoke or fire is detected by one of these devices, the system will discharge CO₂ cylinder. It will also activate the building fire alarm. This system also has a manual release at each wet bench, which is for emergency use only. If you see a fire prior to automatic release of the CO₂, activate the manual release. Activation of the manual release will activate the building fire alarm.

If you identify a fire in progress, pull the manual fire alarm. Only trained individuals should use a fire extinguisher. Fire extinguishers should only be used after the fire alarm is pulled and if you have a clear evacuation route and do not feel you are in personal jeopardy.

Other Life Safety Features

- ABC type fire extinguishers are in the each rooms inside cleanroom.
- Emergency eye washes and safety showers are located in the cleanroom, chase area and MECH room.
- The fire alarm system is connected to building management system (BMS).

Accidents-injuries/medical/accident Reports

Employees should call 911 if immediate medical attention is required. The Denton fire department dispatch arranges for transportation, ambulance and/or other emergency service as necessary. Accidents and incidents must be reported to the Risk Management to be investigated.

Emergency Response

All emergencies must be immediately reported by calling (940) 565-3000. The caller must provide specific information about the type and location of the emergency.

- Dial (940) 565-3000
- Identify yourself
- State location of incident , Room #
- In stating the incident, describe clearly so that the dispatcher knows exactly what services you need, i.e. Risk Management, medical only or fire and medical.
- Do not hang up until after the dispatcher has hung up

If building evacuation is required, pull the fire alarm. UNT police department is responsible for responding to alarms and reported incidents. UNT police department notifies other emergency services as needed. Gas and chemical incidents are handled with the guidance of the Principal Investigator, and other cleanroom personnel if necessary. In the event one of these people is available, personnel that called in the emergency should identify themselves to emergency response personnel.

Serious Accidents That Require Immediate Medical Attention

- Call 911.
- Administer the following first aid procedures whenever possible:
 - NEVER MOVE OR LIFT AN ACCIDENT VICTIM UNLESS THEY ARE IN DANGER OF FURTHER INJURY. If victim must be pulled to safety, move his body lengthwise and headfirst, with his head and neck carefully supported.
 - If the victim's injuries will permit, summon and wait for trained medical help to arrive. While waiting for help, stay with victim and monitor them while providing comfort.

When injury requires immediate action due to chemical exposure, one of the following may be done while awaiting medical assistance:

Chemical Contact With Skin:

- 1) Flush with water for at least 15 minutes,
- 2) Remove contaminated clothing while water rinsing,
- 3) Get medical attention.

Hydrofluoric acid and mixtures containing HF may not cause an immediate burn sensation; however, it can result in severe burns. Calcium Gluconate gel can be applied after thorough water rinse, prior to seeking medical attention.

The gel is located on wet benches in E152.

Chemical Contact With Eyes:

- 1) Flush with water for at least 15 minutes for acids/solvents. Alkalis should be flushed 30-60 minutes. While flushing, lift upper and lower eyelids,
- 2) Get medical attention as quick as possible, regardless of how eyes feel.

Chemical Spills: Push HAZMAT button, evacuate the cleanroom and inform cleanroom staff about the spill. Only personnel trained in chemical handling should attempt to clean up chemical spills.

Solvents:

- Eliminate source of ignition or sparks.
- Shut off re-circulation fans.
- Use spill pillows or towels to clean up spill.
- Transfer absorbed solvent to Ziploc™ bag provided and send out as hazardous waste.

Acids and bases:

- Use appropriate neutralizer to neutralize spill. This is indicated by color change.
- Shut off re-circulation fans.
- Use spill pillows until all liquid is absorbed.
- Transfer to trash and throw material away.
- Wash floor with water.

Hydrofluoric Acid (HF):

Any spill with HF requires notification of Risk Management using (940) 369-2123.

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

Outside Wet Benches (over one liter)

- Evacuate facility immediately.
- Shut off re-circulation fans.
- Attend to personnel who may have been exposed.
- Notify staff member.
- Call Campus UNT police department ((**940**) **565-3000**) and tell them that you require emergency assistance from Risk Management, unless you require outside assistance such as medical services.
- Do not re-enter facility until cleared by authorized staff personnel and/Emergency Response Commander.

Electrical Shock:

Remove source of energy as soon as possible. Use a long wooden handle or dry towel when moving "live" wires or equipment. Check the victim for pulse and breathing. If necessary, administer artificial respiration and/or CPR.

Swallowed Poisons:

Call Poison Control Center at 800-222-1222

Bleeding:

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

Not Breathing:

Start artificial respiration as soon as possible.

Fractures:

Do not move victim unless ABSOLUTELY NECESSARY.

Thermal Burns:

Do not attempt to remove clothing.

AFTER HOURS EMERGENCY RESPONSE

Call **(940) 565-3000**, UNT police department follows a written emergency response plan. The plan calls for contacting the appropriate emergency resources and on-call Risk Management representatives.

FIRE

UNT police department immediately notifies the Denton Fire Department of any reported fire. UNT police department notifies Risk Management representatives.

Toxic Gas Alarms

UNT police department receives notification of toxic gas alarms under certain conditions. When gas concentration exceeds specific limits in UNT cleanroom, the building fire alarm sounds. When the alarm sounds, UNT police department also receives notification.

Upon receipt of an alarm, either Denton Hazmat or Fire Department is contacted as well as UNT police department and the Risk Management. The specific response is outlined in a response matrix which corresponds to the particular alarm (Appendix II).

4) System Failures & Programmed Responses

To the extent practicable, failures of the cleanroom systems have been anticipated and result in clean room gas shutoff.

Possible system failure and response actions are identified below.

Power Failure

All occupants of the cleanroom facilities must leave the facility in the event of power failure after assuring the equipment is left in a safe condition. All toxic and flammable gas systems fail-safe closed when power is interrupted. Emergency power is provided for interspersed lighting, fire protection systems, gas detection systems.

Evacuation of the cleanrooms are still necessary despite the operational status of these systems. Upon the restoration of power, all equipment shall be checked prior to re-initializing hazardous gas services.

Fume Hoods and Exhaust Fans

During a power failure, Nanofab cleanroom fans will momentarily lose electrical power. There will be a decrease in exhaust when power fails and there will be no air supply through building fans. The cleanroom and gas rooms will be under negative pressure with respect to the hallways.

Chilled Water

Equipment dependent upon chilled water for cooling shall be automatically interlocked in case of process cooling water failure.

Breathing Air

The cleanroom have access to breathing air system (SCBA) located in E151 for use during processes which are potentially hazardous. The source of air is from cylinders. A 30-minute escape unit is included with each respirator. Only authorized personnel may use the breathing air system.

5) Hazardous Materials

Compressed Gases

Gas Procurement

All hazardous and flammable gases must be maintained in a designated, ventilated cabinet in a gas storage room. 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 cleanroom advisory committee.

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 students' 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 with RKI portable gas detector, according to the leak check procedure, prior to going into the facility.

Precautions

The following is a list of precautions that should be followed in order to minimize hazards associated with any compressed gas: All gas cylinders, full or empty, shall be handled in the same manner.

- 1) Do not transport gas cylinders without valve protection cap in place unless properly mounted for use on a service cart.
- 2) Do not roll cylinders or use for support.
- 3) Close valves tightly after use.
- 4) Do not place cylinders near furnaces or any source of heat. The cylinder temperature should not exceed 125°F.
- 5) Appropriately secure cylinders so that they can't be knocked over.
- 6) Do not drop cylinders or handle them roughly.
- 7) Do not expose gas cylinders to continuous dampness, salt, corrosive chemicals or fumes.
- 8) Do not attempt to repair or alter cylinders or valves. If a cylinder is damaged or leaking, inform staff personnel.
- 9) **Never completely empty cylinders. Leave at least 5 pounds of pressure in the cylinder.**
- 10) Preserve and comply with all markings and signs applying to compressed gas equipment and system.
- 11) No smoking is permitted while compressed gases are being used or handled.
- 12) Never have oils come in contact with compressed oxygen.
- 13) Always use non-sparking tools on compressed gas cylinders.
- 14) All hydrides must be ordered with DISS (Diameter Index Safety System) fitting and restrictive flow orifice (RFO).
- 15) All hazardous gases will be ordered with restrictive flow orifice (RFO).
- 16) Hazardous gas cylinders can only be transported through the main entrance of Discovery Park on first floor.
- 17) Tag cylinders "used". Do not write on cylinder.

Gas Receiving and Transportation

Cleanroom and risk management staff will have primary responsibility for receiving, leak testing, inter-building transportation, exchange, and hookup of hazardous gas cylinders. The designated risk management staff must be certified in the use of Self-contained Breathing Apparatus (SCBA) and cleanroom staff must be trained in the use of the cabinet gas manifold.

Vendors will be required to schedule deliveries in advance. Upon arrival at the loading dock, the vendor's driver will call the laboratory to announce the arrival of the gas cylinder(s). The designated gas transportation persons will bring a portable gas detector and observe the following protocols:

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 Hazardous Gases to UNT Nanofabrication Cleanroom

1. Two people must be involved with the movement of hazardous gases.
2. Cylinders must be leak checked, according to written protocols in gas room E171 or E172.
3. Cylinder is transferred by cylinder cart.
4. After the used cylinder has been removed from system, remove it from the facility in the same manner that the charged one was brought up.
5. Schedule return of empty cylinder.

Leaking cylinder:

If a cylinder is found to be leaking, do not remove it from the gas cabinet. Immediately notify the Risk Management and vendor representative so that a mutually agreeable solution can be reached for cylinder returns.

Cylinder Change Procedure:

Only qualified personnel (i.e. as described previously) are allowed to transport, handle, install or change a hazardous gas cylinder.

New or replacement cylinders must be installed in a gas cabinet upon receipt and cylinders may not be stored in anticipation of installation at a later time.

SCBA must be worn when changing hazardous cylinders.

CRYOGENIC FLUIDS

General

Cryogenics such as liquid nitrogen and helium are used in cold traps for vacuum systems and process gases

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 safety glasses should be worn. When filling large dewar from holding tank outside, ear protection is worn along with safety glasses 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 VENTILATED HOOD, NEVER INHALE VAPORS, 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 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 severe 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, exposed area should be flooded with water under 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 III with some of their hazards. This list is not a replacement for Material Safety Data Sheets (MSDS). Before working with any chemicals which you are not familiar with, MSDS should be reviewed. Consult Material Safety Data Sheets (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 severe 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 30 to 60 minutes. In the event of skin contact, exposed area should be flooded with water under 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.

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 staff member.)
- All containers must be labeled with their contents and owners name. Otherwise, they will be set aside for disposal and their owner will be suspended from the facility.
- Only chemicals approved by the Facility Manager may be stored in the facility.

Handling

- Always know the hazards before handling any chemicals. Read the Material Data Safety Sheets.
- 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 lint-free wipes. Rinse towels with DI water before disposing in plastic lined trash container (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 wipes.
- 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 freight elevator only.

Hazardous chemicals are not allowed down main corridors.

- Excess quantities of chemicals are to be stored in E173 in the cabinets.

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, 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 (only at room temperature):

- The acid neutralization system will handle room temperature acid.
- Only drain the acid tank at ROOM TEMP and dump rinse the tank with DI water
- Clean area around acid tanks after emptying tanks or completing an operation.

Disposal of solvents:

- Aerated solvent bottles are used as waste containers for solvents.
- Waste bottle should be clearly marked for appropriate waste to be collected.
- Solvent collection system will collect drained solvent waste to a 55 gallon drum
- Solvent waste pick-up is scheduled by UNT risk management through online form ((940) 565-4751).

Chemical hood operations

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 section Chemical Safety).
- 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.
- 5) **Never** submerge gloves in acids or solvents (pinholes are sometimes present). Gloves can be checked by using nitrogen guns to inflate glove then 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, 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.

Characteristics of Some Approved Chemicals

Acetone and Flammable Solvents

Acetone is widely used throughout the facility. It is a very flammable solvent with a low flash point, (i.e. it can be ignited at a low ambient temperature). Because of this it presents a significant fire hazard. A spill of a gallon bottle of acetone could cause a catastrophic fire or explosion. Solvents should also be handled with care in the hoods and not used near hot plates. Spilled solvent can be ignited by the hot plates. The resulting fire could easily be drawn up

into the exhaust ducts, again with catastrophic consequences. Spilled solvents can react explosively with chemical oxidizers present, e.g., peroxides, nitric acid. Spilled solvents should be contained immediately with spill control pillows. Environmental Health and Safety should be called for emergency response and to assist in clean up.

Hydrofluoric Acid

Hydrofluoric acid, HF, presents a significant hazard for personal injury. It is widely used in the lab in its pure form, diluted, and as the active component of BOE, Buffered Oxide Etch. It is used for etching silicon dioxide and particularly for stripping the native oxide prior to further processing. HF, however, is a very hazardous chemical, much more so than any of the other acids. Its danger comes from its effect on flesh. At the concentrations used in the laboratory, an HF "burn" is initially painless. The person may not even know that they have gotten a splatter on their hands, arms, face, or in their gloves. The acid however will silently eat away at the flesh. The fluoride ion is not consumed in this process and is soluble in tissue, so the damage penetrates deeper and deeper, until it comes to the bone where the excruciating pain begins. At that point though, it is too late to reverse the considerable tissue damage. At some point, it enters the blood stream scavenging Ca^{+2} ions, and totally messing up the ionic chemistry of the nervous system. If left untreated, serious injury or death will result. Simple washing of an HF splash is not sufficient to prevent damage. It does not wash off; it is already dissolving flesh and will continue to do so until medical attention specific to HF burns is given (including deep injections to neutralize the penetrated acid). Be sure that medical personnel know that it is an HF burn and know that it requires specific treatment different from a common acid burn. The recommended first aid for HF exposure is to rinse for 5 minutes and then immediately apply the Calcium Gluconate liberally to the affected area. Calcium Gluconate is located in the first aid cabinets in the facility. HF etches silicon dioxide very well. Therefore, it also etches glass. It must not be kept in a glass bottle, used in a glass beaker, or disposed in a glass waste bottle. Plastic labware is available for this purpose. HF, like all other chemicals, must only be used in the chemical hoods. It is not acceptable to take a beaker of acid into the process area to strip a sample just prior to loading in a vacuum system.

Piranha Etch and Nanostrip

Piranha etch is a common name applied to a mixture of Hydrogen Peroxide and Sulfuric Acid (typically 1:5). It is extremely aggressive toward organic materials (e.g. flesh and photoresist residue, equally). It also removes heavy metal contamination. It is commonly used in the semiconductor industry for wafer cleaning. It is difficult to dispose of this mixture, however, as the waste continues to react and decompose for a long period of time. This builds up pressure in the waste bottles causing them to burst. Also if the solution is mixed very peroxide rich, one can make unstable compounds. Therefore, Piranha is not allowed to be mixed in the chemical hoods. It can only be processed in the Hamatech automatic wafer processor. Instead of Piranha etch, the facility stocks Nanostrip, a commercial stabilized version of Piranha.

Tetramethylammonium Hydroxide

Tetramethylammonium Hydroxide (TMAH) exists in several different forms at the CNF. The most common usage is in dilute (<4%) aqueous solutions for developing photoresists. These developers are often referred to by their brand names, so it can be hard to determine without the MSDS, which developers contain TMAH and which are based on other bases. The CNF also has available concentrated TMAH in water (~25%) for selective etching of silicon. TMAH in this form is significantly more hazardous than the dilute solutions used in the lithography areas. In addition to the corrosiveness of the material, concentrated TMAH is also highly toxic. The increase in toxicity of concentrated TMAH is much more than the increase in concentration. It is important for users to treat the concentrated material with much more caution, and not view it as simply a more concentrated developer. Users should note that there are separate waste containers for the concentrated TMAH, and that the usage of this concentration of TMAH is limited to the Base / Solvent hoods.

Chlorinated Solvents

Chlorinated solvents (chlorobenzene, trichloroethylene, and methylene chloride) are used in various resist processes. They are particularly bad for the human body, causing cancer, organ damage, etc. They should not be mixed with normal solvents in waste bottles. There are separate waste bottles for chlorinated solvents. As with most solvents,

they can be readily absorbed through the skin. Rinsing of containers that contained chlorinated solvents requires a special procedure to ensure the material is completely removed. See section 9 for more information.

Glycol Ethers

Commercial photoresists and electron beam resists are dispersed in a variety of solvents. The composition of these mixtures is generally not disclosed on the bottle; you must look on the MSDS for it. One family of chemicals, the glycol ethers, is commonly used in photoresists, and masquerade under a variety of names. In addition, the common trade name "Cellosolve" is often thrown in. Methyl Cellosolve, Ethylene glycol mono methyl ether, and 2-methoxyethanol are all the same thing. Similarly, Cellosolve, Ethyl Cellosolve, 2-ethoxyethanol (2EE), and Ethylene glycol mono ethyl ether are all the same solvent. To further complicate things, each solvent has an acetate relative, so we have Cellosolve Acetate, Ethyl cellosolve acetate (ECA), Ethylene glycol mono ethyl ether acetate, and 2-Ethoxy ethyl acetate which are again all identical. Most photoresists contain one or more of these as solvents. The present solvent of choice is PGMEA (propylene glycol mono methyl ether acetate) also known as 1-Methoxy-2-propanol acetate. Members of this family of chemicals have been shown to be teratogenic and have other effects on reproduction in laboratory animals. A number of studies funded by IBM and others have found evidence that these chemicals can lead to miscarriage and other reproductive effects. To quote from the MSDS for AZ 2131 Thinner (2 Ethoxyethyl Acetate and N-Butyl Acetate) "In studies with laboratory animals, 2-ethoxyethyl acetate caused birth defects, increased fetal death, delayed fetal development, caused blood effects, testicular damage and male infertility." The liquid and vapor are eye and respiratory tract irritants and may cause kidney damage, narcosis, and paralysis (in simple terms, it damages your kidneys, eyes, lungs and brains). Primary routes of exposure are inhalation, skin absorption, and skin and eye contact with vapors. N-butyl Acetate, the other component of this thinner, has a similar list of possible systemic effects. As with all chemicals, these are only the effects we know about. These experimental laboratory exposures were large amounts but nonetheless it is prudent to be careful with these solvents. Review Section 8.6 regarding use of the lithography chemical hoods to ensure that exposure to these compounds is minimized.

Peroxides

All peroxides are highly oxidizing materials. Considerable energy can be released in their reactions with common materials. Some peroxide compounds are unstable, and can explode. The Hydrogen Peroxide in the facility is over 10 X more concentrated than the solution used in the medical field and has a high contact risk. Extreme care should be used in mixing solutions containing peroxides. Peroxides are incompatible with all forms of organic solvents and flammable materials.

Users should be careful when disposing of pure hydrogen peroxide solutions in waste bottles. The waste should only go into waste bottles explicitly listed as accepting pure hydrogen peroxide. Adding pure hydrogen peroxide to an ammonium hydroxide / hydrogen peroxide or hydrochloric acid / hydrogen peroxide waste bottle can lead to rapid heating and breakdown of the peroxide, which can result in the waste bottle being over pressurized and rupturing.

Acetic Acid CH_3OOH , Vinegar. Pungent odor, like vinegar.

Hazards: Corrosive, irritant, may cause burns. Do not induce vomiting.

Flammability: Moderate. Keep away from oxidizers, like peroxides and nitric acid.

Classification: Organic acid. Handle like solvent.

Acetone $(\text{CH}_3)_2\text{CO}$, Dimethyl ketone. Fragrant, mint-like odor. Highly volatile.

Hazards: Defats skin; mild irritant; less toxic than most solvents.

Flammability: DANGEROUS. Keep away from sparks and ignition.

Classification: Solvent

Aluminum Etch (H_3PO_4 [79%], CH_3COOH [5%], HNO_3 [5%], H_2O [11%]). Pungent odor of vinegar.

Hazards: Corrosive, irritant, can cause burns.

Flammability: Low

Classification: Acid

Ammonium NH_4F Colorless crystals, soluble in water.
Fluoride Hazards: Highly toxic, chronic exposure may result in damage to bones and teeth.
Flammability: Non-flammable, but may release NH_3 and HF at fire temperatures
Classification: Salt

Ammonium NH_4OH , Aqua Ammonia. Odor of ammonia.
Hydroxide Hazards: irritating, caustic to skin, eyes. Do not induce vomiting.
Flammability: Low, separate from oxidizing agents.
Classification: Base

Argon Ar. No odor
Hazards: Asphyxiating in concentration.
Flammability: Non-flammable.
Classification: Inert gas

Buffered Oxide NH_4F , HF , BOE, Oxide etch. Odorless, colorless liquid.
Etchant Hazards: Skin contact dangerous. See hydrofluoric acid.
Flammability: Non-flammable.
Classification: Acid

Chlorine Cl_2 , liquid bleach. Amber liquid or greenish-yellow gas; irritating odor.
Hazards: Burns eyes, nose, mouth, etc., can cause nausea, choking, vomiting, pulmonary edema, pneumonia.
Flammability: Not combustible.
Classification: Oxidizer

Diborane B_2H_6 Colorless, sickly sweet odor.
Hazards: Highly toxic, irritating to pulmonary, temporary damage to kidneys and liver.
Flammability: Flammable. Use protein-base foams to extinguish fires never water.
Classification: Gas

Dichlorosilane SiH_2Cl_2 , DCS Colorless, suffocating odor.
Hazards: Pryrophoric; highly corrosive, treat like silane.
Flammability: Flammable, liquefied gas.
Classification: Gas

Disilane Si_2H_6 Silicon hydride
Hazards: Exposure difficult to determine due to spontaneous combustion.
Flammability: Extremely flammable. Small leaks can ignite spontaneously in air.
Classification: Gas

Ethanol $\text{C}_2\text{H}_5\text{OH}$, Ethyl alcohol, grain alcohol Sweet pleasant odor.
Hazards: Normally not very toxic via inhalation. May cause drowsiness, headache.
Flammability: DANGEROUS. Keep away from sparks and ignition.
Classification: Solvent

Freon TF CCl_3CF_3 , Trifluorotrichloroethane Ethereal odor. Environmental concern.
Hazards: Defats skin, irritating to eyes. Higher concentrations may cause dizziness.
Flammability: Slight, avoid open flames. Decomposition products: HCl , HF and phosgene.
Classification: Solvent

Helium He. Colorless, odorless, lighter than air.
Hazards: May be asphyxiating in very high concentrations.
Flammability: Non-flammable
Classification: Gas

HMDS Hexamethyldisilazane Ammonia-like odor, colorless.
Hazards: Contact with water may release ammonia. May cause irritation, headache or dizziness.
Flammability: Moderate
Classification: Solvent (strong base)

Hydrochloric HCl, Muriatic acid, Hydrogen chloride Biting odor, colorless
Acid Hazards: Classification, irritant; may cause burns; do not induce vomiting. Keep away from oxidizers.
Flammability: Non-flammable
Classification: Acid

Hydrochloric acid, ferric chloride Biting odor
Etch Hazards: Corrosive, irritant; may cause burns.
Flammability: Non-flammable
Classification: Acid

Hydrofluoric Hydrogen fluoride, HF. Odorless, colorless liquid.
Acid Hazards: Skin or eye contact extremely dangerous. Nothing is felt at first, but after a latent period, excruciatingly painful tissue and bone destruction may occur and may take up to months to heal. Rinse any suspected skin or eye contact. Seek medical attention.
Flammability: Non-flammable. Release toxic fluoride vapors when heated.
Classification: Acid

Hydrogen H₂ Colorless, odorless, lighter than air.
Hazards: Very slight, asphyxiant.
Flammability: DOT: Flammable. Highly dangerous, may explode or burn in contact with oxygen.
Classification: Gas

Hydrogen HCl, Hydrochloric acid, Muriatic acid. Colorless, pungent odor.
Chloride Hazards: Highly corrosive. Skin, eye, and respiratory irritant; highly toxic.
Flammability: Non-combustible, but contact with metals may release H₂.
Classification: Acid(Gas cylinder is liquid filled under pressure)

Hydrogen H₂O₂, Hydrogen peroxide, peroxide. Heavy liquid. Acrid odor.
Peroxide Hazards: Depending on its concentration, can be severely irritating and cause severe burns.
Flammability: Non-flammable Keep away from solvents and combustible materials. Store one year only.
Classification: Oxidizers

Isopropal C₂H₄OHCH₃, 2-propanol, isopropyl alcohol. Slight sweet odor.
Hazards: Irritant; nervous system depression at higher concentrations.
Flammability: Flammable. Keep away from oxidizers.
Classification: Solvent

Methanol CH₃OH, methyl alcohol, wood alcohol. Colorless liquid. Antidote for ingestion is ethyl alcohol.

Hazards: Absorbs through skin. May cause headache, dermatitis, visual problems, narcosis, can cause blindness or death.

Flammability: Dangerous. Keep away from oxidizers.

Classification: Solvent

Microposit Piperazines, N-methyl-2-pyrrolidinone. Slight amine-like odor. Light yellow to colorless liquid.

1165 Hazards: Corrosive, irritant, may cause burns. Do not induce vomiting.

Flammability: Moderate. Thermal decomposition products include carbon monoxide.

Classification: Organic base.

Nitric Acid HNO₃, aqua fortis.

Hazards: Corrosive; irritant; may cause burns; stains skin yellow.

Flammability: Keep away from flammables

Classification: Acid, Oxidizers

Nitrogen N₂ Colorless, odorless

Hazards: May be asphyxiating in very high concentrations. Liquid nitrogen may cause frostbite or cold burns.

Flammability: Non-flammable

Classification: Gas

Nitrous Oxide N₂O, laughing gas Colorless.

Hazards: Anesthetic, simple asphyxiant.

Flammability: Moderate, supports combustion, can form explosive mixture.

Classification: Gas

Oxygen O₂ Colorless, odorless..

Hazards: None as gas; however, liquid may cause burns.

Flammability: High, supports combustion.

Classification: Gas

Phosphine PH₃, hydrogen phosphide. Colorless, smells like rotten fish.

Hazards: Very toxic; effects central nervous system and lungs; irritating; blood poison.

Flammability: Dangerous, extremely flammable.

Classification: Gas

Phosphoric Acid H₃PO₄. Clear, syrupy, colorless liquid.

Hazards: Corrosive, irritant, may cause burns; do not induce vomiting.

Flammability: Non-flammable. May emit toxic vapors if heated to decomposition.

Classification: Acid

Photoresist Cellosolve acetate, n-butyl acetate, xylene. Red-purple color.

Positive Hazards: Absorbs through skin. Irritant and systemic toxin.

Flammability: Moderate to dangerous

Classification: Solvent

Positive Mild alkaline solution. Amine-like odor.
Photoresist Hazards: Irritating to skin, eyes and lungs.
Developer Flammability: Non-flammable
Classification: Corrosive Alkaline

Silane SiH₄

Hazards: Exposure unlikely due to spontaneous combustion.
Flammability: Extremely flammable. Small leaks can ignite spontaneously in air.
Classification: Gas

Silicon SiCl₄, Silicon chloride. Suffocating odor, colorless liquid.

Tetrachloride Hazards: Severe irritant, emits toxic vapors when heated.
Flammability: Non-flammable
Classification: Corrosive liquid.

Sulfuric Acid H₂SO₄, oil of vitriol. Colorless, viscous liquid.

Hazards: Causes severe burns to skin and eyes.
Flammability: May cause spontaneous ignition of combustible materials.
Classification: Acid

Tetramethyl Developer, TMAH. Strong amine-like odor, clear to yellow liquid.

Ammonium Hazards: Irritant, may cause headache, nausea and weakness.
Hydroxide Flammability: Non-flammable. DOT Corrosive.
Classification: Base

Trans etch H₃PO₄, phosphoric.

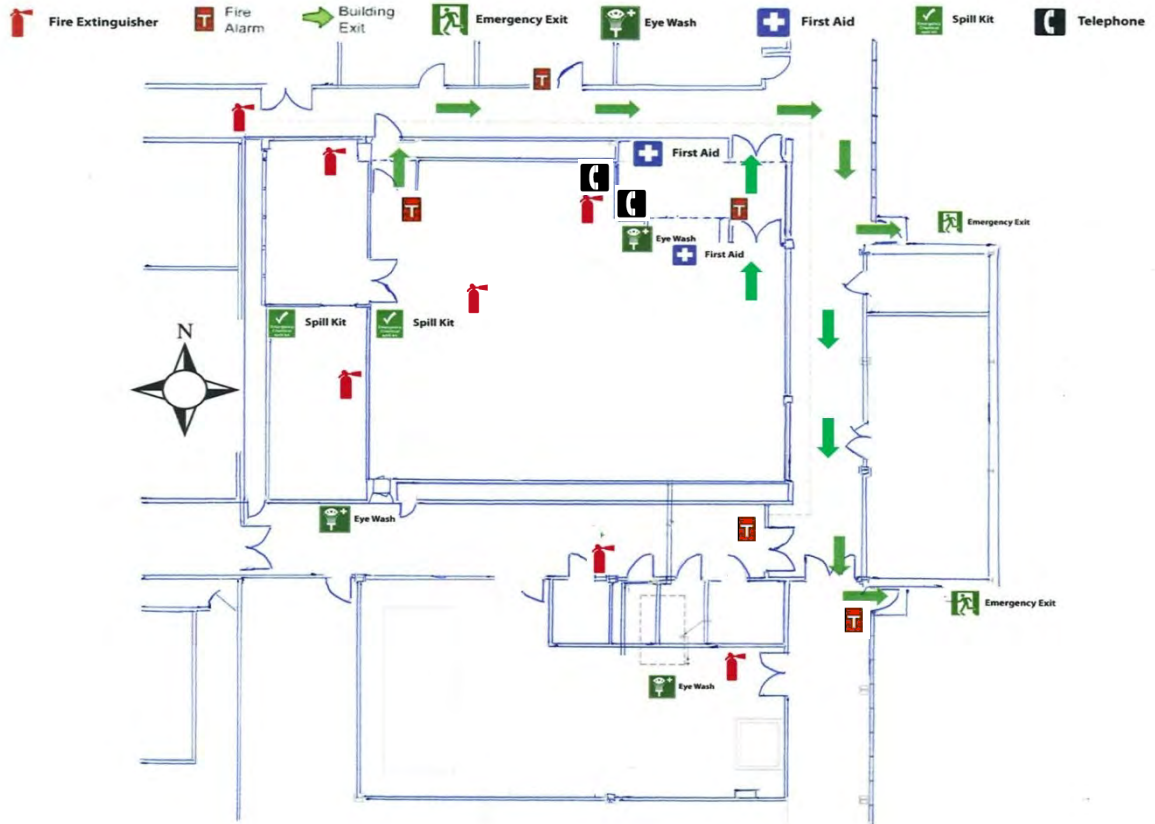
Hazards: Corrosive, irritant, may cause burns.
Flammability: Non-flammable. Emits toxic vapors if heated to decomposition.
Classification: Acid

Triton X-100 Fluorocarbon detergent, surfactant. Clear to slightly hazy liquid.

Hazards: Eye and skin irritant.
Flammability: Non-flammable
Classification: Solvent

THE ABOVE INFORMATION IS A BRIEF OVERVIEW AND IS NOT TO REPLACE MATERIAL SAFETY DATA SHEETS.

Appendix I Emergency Evacuation Plan



Appendix II Alarms and Controls Matrix

CLEANROOM RESPONSE MATRIX											
SEQUENCE OF EVENTS											
OUTPUT ACTIONS	INPUT ALARMS										
	TOXIC GAS*	OXYGEN SENSOR	SOLVENT SENSOR	CONTAINMENT SENSOR	ACID SENSOR	MANUAL PULL	HAZMAT PUSH-BUTTON	GOA PUSH-BUTTON*	FIRE SPRINKLER	BUILDING FIRE	Comments
Shut-off valve in Cabinet	X	X*				X		X	X	X	GOA gas off activation
Building Fire Panel	X	X		X		X			X	X	Toxic Gas detector & pressure sensor of the double wall gas lines
Clean room RED beacon	X					X			X	X	* auto/manual shut off inert gases
BWS goes to full exhaust	X					X			X	X	
Make-up air shutdown	X					X			X	X	
Building Evacuation	X					X			X	X	
UNT - Police Dispatch notified	X	X		X		X	X		X	X	
Denton Fire Dept. notified	X					X					
Denton Haz-Mat notified	X					X					
UNT - RMS notified	X	X	X	X	X	X	X	X	X	X	
Clean Room Mgr. notified	X	X	X	X	X	X	X	X	X	X	
UNT - Fire Systems notified	X	X				X	X		X	X	
UNT - Facilities notified	X	X		X				X			
Clean Room Amber beacon		X					X	X			
Clean Room Bell	X	X					X	X			
Clean Room Evacuation	X	X				X	X	X	X	X	
Maintenance Required			X		X			X			

TOXIC GAS DETECTION & FIRE DETECTION NOTES

GENERAL NOTE: THE DECISION WILL NEED TO BE MADE AS TO WHICH SYSTEM (TOXIC GAS MONITORING SYSTEM OR FIRE ALARM SYSTEM) IS RESPONSIBLE FOR SENDING INITIAL ALARM CONDITION SIGNALS AND ACTIVATING ALARM HORNS AND STROBES WITHIN CLEANROOM AND HOW THE TGMS AND FIRE ALARM SYSTEMS WILL COMMUNICATE. THE TGMS MAY SEND ALARM SIGNALS TO THE FIRE ALARM SYSTEM OR VICE VERSA

1. PRESSURE SENSOR SHOULD BE INSTALLED TO MONITOR THE PRESSURE CHANGE INSIDE OUTER PIPE LINE OF THE DOUBLE WALL COAXIAL TOXIC GAS LINE. WHEN SENSOR DETECTS A PRESSURE CHANGE, IT WILL SEND SIGNAL TO SHUT OFF GAS VALVES IN THE GAS CABINETS AND NOTIFY PARTIES AS DESCRIBED IN NOTE 2. RED LIGHT AND BELL INDICATE A BUILDING EVACUATION IS NEEDED.
2. TOXIC GAS SENSORS SHOULD BE INSTALLED INSIDE THE GAS CABINET EXHAUSTS IN TOXIC GAS STORAGE ROOM TO DETECT TOXIC GASES. WHEN THE SENSOR DETECTS A TOXIC GAS, A SIGNAL WILL BE SENT TO THE VALVE INSIDE THE CABINET AND THE VALVE WILL BE CLOSED. THERE WILL ALSO BE LOCAL ALARM IN THE ROOM. CONCURRENTLY A SIGNAL WILL BE SENT TO A FIRE ALARM PANEL WHICH WILL BE LOCATED OUTSIDE OF THE CLEANROOM. THE FIRE ALARM PANEL WILL SEND A NOTIFICATION TO DENTON FIRE DEPARTMENT, DENTON HAZ-MAT, UNT POLICE DISPATCH, UNT RMS AND UNT FACILITIES FOR AN IMMEDIATE RESPONSE. A RED LIGHT BEACON AND BELL IN THE CLEANROOM WILL NOTIFY EVERYONE TO EVACUATE THE ROOM. A BUILDING EVACUATION IS NEEDED IN THE CASE OF TOXIC GAS LEAK. A HAND PULL SHOULD BE INSTALLED OUTSIDE THE CLEANROOM TO BE USED BY THE FIRST RESPONDERS IN THE EVENT OF A FULL BUILDING EVACUATION. THIS HAND PULL WOULD ALSO SIGNAL THE BMS SYSTEM TO GO FULL EXHAUST AND MAKE UP AIR SHUT DOWN. THE GAS SENSORS WILL COLLECT DATA. THIS DATA WILL BE SENT TO CLEANROOM MANAGER'S COMPUTER TO BE LOGGED AND DISPLAY APPROPRIATE ALARMS.
3. TOXIC GAS SENSORS SHOULD BE INSTALLED IN THE TOOL EXHAUSTS IN THE CLEANROOM TO DETECT TOXIC GASES LEAK INSIDE THE CLEANROOM. SIMILAR ALARM SEQUENCES WILL PROCEED AS INDICATED IN NOTE 2.
4. SPRINKLER HEADS FIRE SUPPRESSION SYSTEMS WILL BE INSTALLED ON ALL THE POLYPRO ACID/BASE WET BENCHES. THE STAINLESS STEEL SOLVENT BENCH HAS A ON BOARD CO2 FIRE SUPPRESSION.

OXYGEN DEPLETION SENSOR

OXYGEN DEPLETION SENSORS WILL BE INSTALLED IN THE INERT GAS STORAGE ROOM 108 AND INSIDE CLEANROOM NEAR THE DEPOSITION TOOLS. WHEN A DECREASED LEVEL OF OXYGEN IS DETECTED, A SIGNAL WILL BE SENT TO THE BUILDING FIRE PANEL ALONG WITH THE ACTIVATION OF AN AMBER LIGHT BEACON AND BELL. THE INERT GASES WILL BE SHUT OFF. THE FIRE ALARM PANEL WILL ALSO NOTIFY UNT POLICE DISPATCH, RMS, CLEANROOM MANAGER AND FACILITIES. A CLEANROOM EVACUATION WILL BE NEEDED IN THIS CASE.

LIQUID CHEMICAL DETECTION

HAZMAT PUSH BUTTON CAN BE USED TO EVACUATE THE CLEANROOM AREA IN CASE OF MEDIUM OR LARGE CHEMICAL SPILL WHICH EXCEEDS THE HANDLING ABILITY OF CLEANROOM PERSONNEL. IT ACTIVATES AMBER BEACON AND NOTIFIES UNT POLICE DISPATCH AND UNT RMS TO RESPONSE.

SOLVENT DETECTION

THE SOLVENT COLLECTION SYSTEM IS PUMPED INTO A DRUM LOCATED IN A STORAGE CABINET IN THE TOOL SUPPORT AREA OUTSIDE OF THE CLEANROOM. THERE SHOULD BE SENSORS INSTALLED IN THE DRUM TO MEASURE THE TANK LEVELS AND NOTIFY THE BMS WHEN THE DRUM NEEDS TO BE REMOVED OR SERVICED. THERE SHOULD BE AN ALARM INSTALLED IN THE SECONDARY CONTAINMENT CABINET THAT WILL SEND A SIGNAL TO THE FIRE ALARM PANEL TO NOTIFY UNIT FIRE AND SECURITY AND RMS FOR AN IMMEDIATE RESPONSE.

ACID NEUTRALIZATION SYSTEM

THE ACID NEUTRALIZATION SYSTEM PUMPS FROM THE PIT LOCATED IN THE TOOL STORAGE AREA TO THE MAIN TANKS LOCATED IN THE MECHANICAL ROOM. THE SYSTEM WILL AUTOMATICALLY NEUTRALIZE THE ACIDS AND WILL DUMP INTO THE SANITARY SEWER SYSTEM. THERE SHOULD BE LOCAL ALARMS ASSOCIATED WITH THIS SYSTEM THAT ARE CONNECTED TO THE BMS SYSTEM. ALARMS SHOULD ALSO BE CONNECTED TO THE FIRE ALARM/TOXIC GAS MONITORING SYSTEM.

GAS OFF ACTIVATION BUTTON

IN CASE OF POWER AND EXHAUST FAILURE, THE GOA BUTTON CAN BE USED TO SHUT OFF TOXIC GAS VALVES AND NOTIFY UNIT FACILITY AND RMS. THE AMBER LIGHT AND BELL WILL BE ON AND CLEANROOM EVACUATION WILL BE NEEDED.

EMERGENCY CLEANROOM EXHAUST AND MAKEUP AIR SHUTDOWN

THIS SEQUENCE SHALL BE ACTIVATED UPON ANY OF THE FOLLOWING INPUTS:

1. TOXIC GAS ALARM.
2. LOCAL FIRE ALARM MANUAL PULL STATION ACTIVATED.
3. LOCAL FIRE SPRINKLER ACTIVATION (FLOW SWITCH).
4. BUILDING FIRE ALARM.

UPON DETECTION OF ANY OF THESE ALARMS, MUA-1 SHALL BE DISABLED. VOC EXHAUST, GENERAL EXHAUST, AND ACID EXHAUST SYSTEMS SHALL CONTINUE TO OPERATE.

ALTERNATIVE: MAKEUP AIR UNIT REDUCES TO IT'S MINIMUM AIRFLOW SETTING OF 30% (ADJUSTABLE).

Appendix III Concentration of Common Chemicals in the Nanofabrication Cleanroom

Chemical Type	Chemical	Formula	Concentration	
Acids and Oxidizers	Acetic Acid	CH ₃ COOH	95%	
	Hydrofluoric Acid	HF	49%	
	Hydrochloric Acid	HCL	36%	
	Nitric Acid	HNO ₃	68%	
	Phosphoric Acid	H ₂ PO ₄	85%	
	Sulfuric Acid	H ₃ SO ₄	96%	
	Hydrogen Peroxide	H ₂ O ₂	30%	
	Aluminum Etch 80-15-3-2	Phosphoric Acid		80%
		Acetic Acid		15%
		Nitric Acid		3%
		Water		2%
	NANO-STRIP	Sulfuric Acid		90%
		Peroxymonosulfuric Acid		5%
		Hydrogen Peroxide		5%
BOE (Buffered Oxide Etch)	NH ₄ -HF	50%-10%		
Bases	Ammonium Hydroxide	NH ₄ OH	25%	
	Ammonium Fluoride	NH ₄ F	40%	
	Potassium Hydroxide	KOH	45%	
	Sodium Hydroxide	NaOH	50%	
	Tetramethylammonium Hydroxide (TMAH)	(CH ₃) ₄ NOH	25%	
Solvents	2-Propanol	CH ₃ CHOHCH ₃	100%	
	Acetone	CH ₃ COCH ₃	100%	
	Chlorobenzene	C ₆ H ₅ Cl	100%	
	Methanol	CH ₃ OH	100%	
	Toluene	C ₆ H ₅ CH ₃	100%	
	Trichloroethylene	C ₂ HCl ₃	100%	
	Xylene	C ₆ H ₄ (CH ₃) ₂	80-90%	

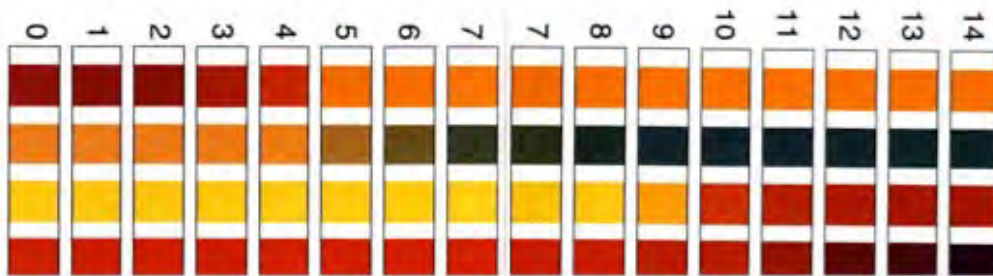
Appendix IV Incompatible Chemicals

Chemical	Incompatible with:
Acetic Acid	Nitric Acid, Ethylene Glycol, Peroxides, Permanganates
Ferric Chloride	Aluminum
Hydrogen Peroxide	Copper, Chromium, Iron, Alcohols, Acetone, Organics
Mercury	Ammonia
Nitric Acid	Photoresist Developer, Acetic Acid, Flammable Liquids, Flammable Gases
All Acids (ex. Hydrochloric, hydrofluoric)	All Bases (ex. Sodium cyanide, potassium hydroxide, sodium hydroxide)
Oxidizers (ex. Permanganates, inorganic peroxides, persulfates, perchlorates)	Flammables, organic materials, reducing agents (ex. Zinc, alkaline metals, formic acid)
Water Reactives (sodium, potassium, metal hydrides, hydrolysable halides)	Water
NANO-STRIP	Solvents
Sulfuric Acid	Solvents

Appendix V How to Read a PH Stick, HMIS III label and NFPA fire Diamond

Method of Application:

1. Dip the BAKER-pHIX test strip into the test solution for roughly three seconds, so that all of the color zones are immersed.
2. Compare the indicator zone (i.e., unprinted area) to the color scale and read off the printed pH



value. By holding the pH strip against light, the pH determination may be facilitated.

[PH Color Chart for Baker -pHIX pH 0.0-14 Sticks -Product No. 4390](#)

[a color image is available online at http://www.louisville.edu/research/cleanroom/lab-safety](http://www.louisville.edu/research/cleanroom/lab-safety)

After a pH stick test on a chemical, an obtained color stick matching color coding pH numbers 0 to 7 indicates that the tested solution is an acidic solution 0 meaning most acidic, 7 meaning least acidic. An obtained color stick matching color coding pH numbers 7 to 14 indicates that the tested solution is a basic solution, 14 meaning most basic. pH 7 is a neutral determinant; in some cases it indicates the chemical solution is a solvent.

How to Read an HMIS III Label

HMIS Stands for Hazardous Materials Identification System.

An HMIS label can be presented with a diamond or with rectangular color bars each representing a different hazard of a particular chemical. The colors used are: **blue** for health, **red** for flammability, **orange** for physical hazard and white for personal protection ratings.

The HMIS labels are not intended for emergency situations, they are used for health warning information.

The following is an example of an HMIS label. Please refer to the following rating denominations to understand the hazard level on each category.



Blue (Health)

- 4= Deadly
- 3= Extreme Danger
- 2= Hazardous
- 1= Slightly Hazardous
- 0= No risk to Health

Red (Flammability - Flash Points)

- 4= Below 73°F
- 3= Below 100°F
- 2= Below 100°F – not exceeding 200°F
- 1= Above 200°F
- 0= Will not Burn

Orange (Physical Hazard)

- 4= Severely Hazardous
- 3= Seriously Hazardous
- 2= Moderately Hazardous
- 1= Slightly Hazardous
- 0= Minimal Hazard

White (Protective Equipment)

- A = Safety Glasses
- B= Safety Glasses and gloves
- C = Safety Glasses, gloves and apron
- D= Face shield, gloves and an apron
- E= Safety glasses, gloves and dust respirator
- F= Safety glasses, gloves, apron and a dust respirator
- G = Safety glasses and a vapor respirator
- H= Splash Goggles, gloves, apron and a vapor respirator
- I = Safety glasses, gloves, and a vapor/dust respirator
- J= Splash goggles, gloves, and a vapor/dust respirator.
- K= Airline Hood or Mask, gloves, full suit and boots.
- L-Z= Custom PPE specified by employer.

How to Read a NFPA Fire Diamond

NFPA stands for National Fire Protection Association.

An NFPA fire diamond represents a standard maintained by the US Fire Protection Association. This diamond will help emergency personnel to easily identify the hazards of a particular chemical during an emergency response.

The following image represents a fire diamond. Please refer to the following rating denominations to understand the hazard level on each category.



Blue (Health)

- 4= Deadly
- 3= Extreme Danger
- 2=Hazardous
- 1= Slightly Hazardous
- 0= Normal Material

Red (Flammability -Flash Points)

- 4=Below 73°F
- 3=Below 100°F
- 2=Below 100°F – not exceeding 200°F
- 1=Above 200°F
- 0= Will not Burn

Yellow (Reactivity)

- 4= May Detonate
- 3= Shock and Heat May Detonate
- 2= Violent Chemical Change
- 1 = Unstable if Heated
- 0=Stable

Specific Hazard

- OX = Oxidizer
- ACID = Acid
- ALK = Alkali
- CORR = Corrosive
- W = Use no Water
- ☸ = Radioactive

References:

- [1] NC State University General MRC Cleanroom Safety & Procedures Manual
- [2] University of Louisville Safety Manual