



Micro/Nano Fabrication Center

Safety Manual

(<http://mfc.engr.arizona.edu/Safety.htm>)

University of Arizona

MFC Safety Regulations Summary

1. Anyone interested in using the Micro/Nano Fabrication facility must go through a **one-on-one safety tour**. Everyone is also REQUIRED to have taken the Risk Management Chemical Safety online course on D2L.
2. Everyone **must wear safety glasses** while in the cleanroom or while working at the chemical wet benches outside of the cleanroom. Contact lenses are not allowed in the cleanroom or when working with chemicals outside of the cleanroom.
3. Everyone needs to wear a cleanroom garment to enter the cleanroom: coverall, hood, boots, and latex gloves when entering the cleanroom.
4. **NO SMOKING, EATING, OR DRINKING IS ALLOWED ANYWHERE INSIDE THE FACILITY.**
5. Anyone using acids or other hazardous chemicals needs to wear aprons, goggles or face shield, and chemical gloves.
6. All chemicals to be used must be cleared through the MFC Manager, MSDSs are REQUIRED for all chemicals brought into the Lab and the MSDS must be available for viewing on the MFC website before any processing is initiated. **NO NEW CHEMICALS MAY BE BROUGHT INTO THE LAB WITHOUT THE APPROVAL OF THE MFC FACILITY SUPERVISOR. AN ELECTRONIC of the MSDS MUST BE FORWARDED TO THE MFC MANAGER for approval.** MSDSs are available for for viewing on the MFC web site at <http://mfc.engr.arizona.edu/Safety.htm>
7. The MFC will provide training on correct chemical handling as needed. Please request training or consult with the MFC Manager if you are not sure on how to handle a chemical.
8. All chemical processing must be done under an approved exhausted fume hood or wet bench.
9. Closed toed shoes are required. **ABSOLUTELY NO SANDALS OR FLIPFLOPS ALLOWED anywhere in the facility.**
10. **ALWAYS CLEAN UP AFTER YOURSELF.** Properly dispose chemicals when you have completed your processing. If you leave the facility and plan to return **COVER AND LABEL ANYTHING LEFT IN THE EXHAUST HOOD / SINK INCLUDING YOUR NAME AND CONTACT NUMBER where you could be reached at all times.** Rinse all containers. Wipe minor chemical spills or water splashes. **Leave the area neat, clean and SAFE for the next user.**

11. **VERIFY IF YOUR CHEMICAL/CHEMISTRY CAN BE SAFELY DIPOSED DOWN THE MFC DRAIN.** If the chemicals are allowed to go down the drain, then use a 10X volume of water to chemical to flush it down. **NO SOLVENTS, ORGANIC CHEMICALS, OR HEAVY METALS MAY GO DOWN THE DRAIN.** If chemicals cannot be disposed down the drain, they must be placed in properly labeled waste bottles.
12. Empty chemical bottles must be rinsed out thoroughly with water prior to disposal. They can be tossed into regular trash if you are certain that all traces of the chemical have been rinsed out. For acids and bases a pH paper strip can be used to test for residual acid or base that may be present in the container.
13. If chemicals are splashed on you, **RINSE ANY AFFECTED AREA IN RUNNING WATER IMMEDIATELY.** Hands in the sink, eyes in the eyewash, and rinse for 10 minutes. If the effected area is large remove all clothing. step directly into the safety shower and remain in the shower for at least 5 minutes. Seek medical attention immediately. There is an HF neutralizing cream, Calcium Gluconate, available in various locations throughout the facility to treat minor HF burns.
14. MFC Staff will train students on the use of lab equipment. **DO NOT USE ANY EQUIPMENT YOU HAVE NOT BEEN PROPERLY TRAINED TO USE. DO NOT USE ANY SHORTCUTS WHEN OPERATING EQUIPMENT. YOU MUST LOG IN THE LOGBOOK FOR EACH EQUIPMENT YOU USE.** Log all appropriate information each time the equipment is used and alert staff to any safety issues.
15. Know where all the **FIRE EXITS** and **FIRE ALARMS** are located around your work area.
16. In case of a fire alarm: **EXIT IMMEDIATELY.** If it is a fire drill, go to the nearest fire exit and meet outside the South entrance of the ECE building. **DO NOT STOP TO TAKE OFF CLEANROOM/LAB GARMENT.**
17. In case of a fire, get to the nearest fire exit and **PULL THE FIRE ALARM AS YOU IMMEDIATELY EXIT THE BUILDING. DO NOT STOP TO TAKE OFF CLEANROOM/LAB GARMENT.**
18. All broken **glass, quartz, or wafers must be disposed of in the designated "SHARPS" containers.** Please alert staff if lab glassware is broken.
19. Walkways and aisles must be kept free from obstructions at all times. A 3 feet wide corridor must always be available to walk through in any work area.
20. Immediately report any hazardous conditions or any unsafe behavior to any MFC staff member.

I. MFC Safety Regulations (Detailed)

II. I - Introduction

A. Why this document?

This document describes basic Rules & Procedures for persons using the Micro/Nano Fabrication Center (MFC). This document does not overrule any additional University safety guidelines. This document does not list every case or problem that may occur. Each lab user is still responsible for the use of common sense. Remember, if there are any questions please feel free to ask any MFC staff member for assistance.

B. The Lab Users Responsibility

1. The users are welcome to work in the MFC lab, but there are rules that they must follow, these rules fall under into 3 general groups, ***Safety, Recordkeeping, and General***. It is important to keep in mind that first there are many lab users working in the lab and each needs to have a clean and safe area.
2. It is the responsibility of each user, to follow the rules, keep the area clean, and leave the area as clean as you would like to find it the next time you enter the lab. If there are any problems within the work area i.e., the tools or anyone finding someone not following these safety rules or cleaning up, please contact the MFC Staff, as soon as possible.
3. Each user must:
 - a) Have completed or be enrolled in the next ***University Laboratory Safety Training***, this class is the General Laboratory Chemical Hygiene Training (i.e., Lab Safety Training) and can be found at this website:
<http://fp.arizona.edu/riskmgmt/training.htm>.
 - b) You must also complete the “**User Access Form**” (a copy can be found our website: <http://mfc.engr.arizona.edu/index.html>). Please read and complete each portion of the form, then have your PI sign the form and get an understanding of the costs of using the lab. Should you have any questions, please contact an MFC Staff member.

C. The MFC's Role

1. The MFC staff wants all users to be able to produce your data and results needed in a safe and timely matter. The lab staff will work to keep the tools up and in proper working order.
2. MFC supplies a variety of chemicals in the lab for general use. Details of these chemicals can be found on our website under Safety/MSDS. **Please Note:** that in some cases, (i.e., Photo Resist), we will work to keep these chemicals on hand, but the same type of chemical may not be available at all times, the lab may substitute a similar chemical, if your work needs the exact same chemical, e.g. photo resist, then you may need to supply your own chemical.

3. Housekeeping is the duty of ALL lab users in order to keep the area safe. When users do not clean up, the cost for the MFC staff time needed to clean along with any additional cleaning supplies will be billed to the PI.

4. The goal of the lab is to keep the equipment up and ready for use, (see our website: <http://mfc.engr.arizona.edu/equipment.html>). Maintenance of equipment both planned and unplanned will sometimes bring tools down, the goal of the lab is to have a tool uptime of greater than 85%.

III. Gases, Acids, Chemicals & Cryogenic Liquids

A. Lab users vs. Chemicals

1. Care is needed when using all chemicals, the chemicals within the lab fall into 2 types or categories; chemicals that MFC supplies and chemicals that a lab user supplies.
2. All MFC chemicals have the Material Safety Data Sheets (MSDS) online on our website: <http://mfc.engr.arizona.edu/safety/MSDS.htm>.
 - a) This page lists the supplier, area of storage, and the waste stream for each chemical.
 - b) Please read directions carefully and use only as directed by the instructions.
3. Do not use any of the lab chemicals without having completed a full review of the chemical, safety & waste stream with a member of the MFC staff.
4. If at any time you have a question about a chemical or its processing factors, contact a MFC staff member before working with the chemical.
5. Users may bring chemicals into the lab, but they must follow some rules and guidelines. Before any chemical is brought into the lab, you must do a review of the chemical with the MFC Lab Manager. During this review, you must have:
 - a) Supply MFC with an up-to-date copy of the MSDS for the chemical under review. An emailed pdf format version of the MSDS is preferred.
 - b) Know the waste stream for this chemical for disposal purposes.
 - c) Know the proper storage for the chemical.
 - d) Provide the dates the chemical will be needed to complete the project, and who will remove chemical from lab when project is finished.
 - e) Know the lab safety Personal Protective Equipment (PPE) and how to properly handle and dispose of the chemicals used.
 - f) There must be a review of the fire code needs for the chemicals; this will only be needed for a few of the class CSL 2 or 3 chemicals. The volume of the chemicals, (liquids or gases) may be limited based on the hazard classification.
 - g) Chemicals must remain in their original bottles with the owner's name, phone number and date brought into lab, clearly marked for identification.
6. After the review with Lab Manager or the Staff Engineer, and if you were given the approval to bring in the chemical(s) into the lab, you will need to make certain that the rules that have been set during the review are followed and completed throughout the use of this chemical in the lab. All chemical(s) brought into the lab for use by a single individual or group must have the bottle clearly marked for identification purposes, as described above. You will also need to be sure that the chemicals are removed after the completion of the project and that MFC staff have been notified in writing. You or your PI may be charged for the removal and disposition of the chemicals if the chemicals are not removed and the MFC staff are not notified in writing.

B. Material Safety Data Sheets (MSDS) Requirements

1. All chemicals used in the lab must have an MSDS on file with the MFC lab. MSDS's can be found on our website: <http://mfc.engr.arizona.edu/safety/MSDS.htm>. These MSDS's contain all the key directions and information about the chemical. You are responsible to review and understand the MSDS for any chemicals you use.

C. Chemical Storage and Uses

1. Chemical storage falls into two types, "in use" chemicals and chemicals in storage.
 - (1) All chemicals in use are to be stored at or near the equipment that uses this chemical.
 - b) All open containers in use are to be kept tightly sealed, in the same container as they were when first opened.
 - c) Mark the container with the date it was opened or initially used. All chemicals supplied by a lab user must have the **full name of the user** and a **valid contact number** on the bottle and **must be dated**.
 - d) Each container must have all of the key information of the chemical clearly marked and readable, if not, it is to be remarked or disposed of.
 - e) Chemicals placed on the floor need to have a secondary containment, i.e., chemical resistant tub, to prevent spreading of spilled material in case the bottle breaks or cracks.
 - f) Only one bottle of any type of chemical should ever be opened at any given time in each area.
2. If chemicals are in use, then:
 - a) The user should be with the chemicals at all times.
 - b) If the user can not be with the chemical set up, then all beakers and glassware containing any chemical must be labeled to describe their contents, the users name and a contact number. This includes water and solvents!
 - c) No open chemicals are to be left unattended for more than 24 hours under any circumstance. If chemicals are to be re-used, remove and store in appropriately labeled bottles.
 - d) If any chemicals are found without labels or users, all items will be taken as unattended, the lab will clean and wash the glass ware and any test items will be discarded. The PI will be billed for the staff clean up time and any additional cleaning supplies/chemicals.
 - e) When you complete your work, clean up after yourself. If you do not, this is a major safety infraction and will be treated as such.
 - f) If you come up to any station in the lab and encounter any unknown liquids spilled in the working area, perform a full wash down of the area and test with pH paper.
3. If the chemical is to be stored unopened, then they must be stored in one of the chemical bunkers for liquids or in the gas bottle holding area if it is a gas bottle. Lab staff will help, if needed

D. Person Protective Equipment (PPE)

1. Protective equipment may be needed for:
 - a) Eyes

- b) Face
 - c) Extremities
 - d) Protective clothing
 - e) Respiratory devices
 - f) Protective shields and barriers
2. PPE is made to protect users from hazards in the following categories:
- a) Processes
 - b) Environment
 - c) Chemicals
 - d) Mechanical irritants
 - e) Causes of injury or impairment
3. All PPE must be:
- a) Adequate
 - b) Properly maintained
 - c) Sanitary
4. General rules for PPE
- a) Care should be taken to recognize the possibility of multiple and simultaneous exposure to a variety of hazards. ***Use adequate protection against the highest level with each of these hazards.***
 - b) Defective and damaged equipment must not be used.
 - c) PPE must fit properly.
 - d) Users are accountable to comply with all PPE safety rules including:
 - (1) The correct use and care for PPE safety.
 - (2) Reporting and replacing defective PPE.
 - e) Re-training will be needed whenever:
 - (1) Lab staff believes user lacks skill or understanding.
 - (2) Changes in the types of PPE used that has changed from previous training methods or that is outdated or changed to improved PPE safety for users.
 - (3) Requests from a MFC staff, lab user, PI or co-worker.
 - f) The cleanroom has a “Buddy” rule which takes place after normal hours, between 5 pm and 8 am on normal weekdays, weekends or University holiday’s. This means that you must not work in the cleanroom by yourself. Another qualified MFC user should be present and aware of your presence in the lab. Don’t hesitate to stop and introduce yourself to your fellow lab users at anytime during your visit in the cleanroom.
5. Users must be trained on:
- a) When it’s should be required to wear PPE when working in lab.
 - b) How to properly dress, remove, adjust, or when one is required to wear PPE.
 - c) The limitations and why PPE is important.

- d) Proper care of PPE including maintenance, physical life, repair and disposal.
- e) Lab users must *demonstrate* understanding and demonstrate the ability to properly *before* using PPE.
- f) MFC staff must properly inspect PPE before allowing lab user to handle.

6. Eye and Face Protection

- a) Protective glasses or goggles are required in the Clean Room at all times, unless you are working on a microscope to observe work.
- b) Face shields should be worn over primary eye protection (glasses or goggles) when pouring chemicals
- c) Lab users, who wear prescription lenses must wear either protective devices fitted for prescription lenses or protective devices designed to be worn over regular prescription eyewear.
- d) Contact lenses can not be worn in the Clean Room. They may only be worn in the Chase area, if there are not any chemicals being used.
- e) Eye and face protection is required for all chemical processes and when transporting chemicals in the lab, use when handling:
 - (1) Liquid chemicals
 - (2) Acid and caustic liquids
 - (3) Chemical gases or vapors
 - (4) Cryogenic Liquids

7. Respiratory Protection-

- a) The MFC labs primary objective is to prevent atmospheric contamination through the use of engineering controls:
 - (1) Enclosing or confining operation
 - (2) Ventilation
 - (3) Substitution with less toxic materials
- b) If the above requirements can not be fulfilled in the work area, then appropriate respirators must be used.
- c) Because the lab does not use or teach the use of respiratory equipment, we strongly recommend that outside services be used for processes that require respiratory protection.
- d) If you need to use respiratory equipment, then meet with the lab manager to review your needs and to ensure the safety of those who work in the lab.
- e) Any action that requires respiratory equipment will need approval from the lab manager. If the lab manager approves the use, then proper training will be needed, please contact Risk Management and complete training before use.

8. Hearing Protection

- a) Protection against the effects of noise must be used when any user is exposed to noise levels that exceed:

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

b) If noise exposure can not be reduced below the levels above, PPE must be used. At this time, the lab does not have an area that currently needs hearing protection, but under some work conditions (i.e., when using hand tools) one may need to use hearing protection.

9. Hand Protection

a) Lab users must wear appropriate hand protection when exposed to hazards from:

- (1) Absorption of harmful chemicals
- (2) Chemical burns
- (3) Thermal burns
- (4) Harmful temperature extremes (both high and low)

b) Gloves can protect you from the hazards of chemical spills or equipment or tools burns.

c) The lab has 3 types of safety gloves you can use. They are gloves for Acid, Solvent and Extreme Temperature (both low and high).

d) Gloves must not be worn when a worker is exposed to moving parts in equipment and tools or where they might get hands or fingers caught. Always use caution when working or handling chemicals or equipment.

E. Waste Stream (Disposing of Chemicals)

1. Knowing and using the proper waste stream for each chemical is very important. Improper waste stream can cause problems with the environmental discharge from the lab and a safety problem for lab users.

2. The waste stream for all MFC supplied chemicals is listed on our web page (<http://mfc.engr.arizona.edu/safety/MSDS.htm>).

3. In general, there are 2 main waste streams, they are the,

- a) AWN (Acid Waste Neutralization system)
- b) Storage Bottles (plastic or glass containers)

4. The Acid Waste Neutralization stream is used for:

- a) Most acids chemicals
- b) Most base chemicals
- c) Small amounts of HF/BOE

- d) NOT to be used for Solvents or heavy metals (i.e., metal etch)
5. Storage Bottles
- a) Large amounts of HF/BOE (Greater than 250 ml/day)
 - b) Any metal etch (i.e., Aluminum or Copper Etch)
 - c) All solvents including Photo Resist Striper and Photo Resist
6. How to use the Acid Waste Neutralization stream
- a) This chemical stream is used by pouring the chemicals down the drain in the sinks. All sinks drain to into the Acid Waste Neutralization system.
 - b) Before using or dumping chemicals into the waste stream, you must:
 - (1) Review all other sections of this document and follow instructions
 - (2) Let chemical cool to within 5° C of room temp.
 - (3) Start running the water in the sink before dumping chemical
 - (4) Slowly (< 1 L/min.) pour the chemical down the drain
 - (5) Let the water run for 5 minutes after you have completely poured in the chemical and wash down the sink and area around the sink.
 - (6) If you are pouring a second chemical down the drain, you must follow the above procedures, do this for each chemical you are dumping and finish all steps above before starting to dump the next chemical.
7. How to use the storage bottles for chemical waste.
- a) This chemical stream is to pour the chemicals into a bottle.
 - b) To use this waste stream you must:
 - (1) All other sections of this document must be followed
 - (2) Let cool to within 5° C of room temp.
 - (3) Ensure that the bottle to be used to store the waste is:
 - (a) Larger than the amount of material to be add to the bottle
 - (b) The bottle material is compatible with the chemical being added (use of the same bottle works best).
 - (c) If you are using an existing bottle, ensure that the contents of the bottle are fully compatible with the chemical you are adding. This is very important, if you do not know, ask or use a fresh, clean bottle.
 - (d) The bottle must be fully marked for the type of waste.
 - (4) Slowly (< 1 L/min.) pour the chemicals into the bottle
 - c) If the bottle is full or near full, it should be marked for waste removal and place in the waste holding area, in the water room. Any member of the MFC staff can show you were this area is.
 - d) Mark the bottle with one of the tags supplied by the lab. Fill in all information requested on the tag.
 - e) To remove the bottle, follow the steps listed in Section II subsection G.

F. Request for chemicals

1. Lab supplied chemicals

- a) MFC Staff will supply the lab supplied chemicals as needed. Please contact any staff member with your requests. For a listing of Lab supplied chemicals, please see the web page: (<http://mfc.engr.arizona.edu/safety/MSDS.htm>)
- b) Note: the staff works the standard University work week day shift; there will not be anyone here after 5pm, weekends or standard University holidays and shutdown periods. **Please plan ahead.**

2. User supplied chemicals

- a) Standard reorder—
 - (1) Small volumes of user supplied chemicals that have been approved by the lab manager (see section # II subsection A) may be taken into the lab by the user.
 - (2) Care must be used to move any chemical into or out of the lab.
 - (3) If there is more chemical containers than will be used at one time, the extra containers are to be stored per lab policy.
- b) Toxic/ Pyrophoric Chemicals
 - (1) All Highly Toxic and Pyrophoric chemicals must be reviewed by the lab manager each time they are added to the lab.
 - (2) This review will cover safety and total volume of each chemical.
 - (3) There may be extra rules for moving the chemicals into the lab, and the amount to be stored in the lab. See the Lab Manager for details.

G. Transport into or out of the Cleanroom

1. Liquid

- a) All liquid chemicals are to be transported into the Clean Room from the storage bunkers by use of a transport bucket. The bucket will hold >125% of the chemical and be compatible with the chemical being transported.
- b) The bucket with the chemical will be placed next to the Clean Room wall just on the outside of the Clean Room so that it can be easily retrieved inside the Clean Room.
- c) After the bucket is placed outside the wall, go into the Clean Room and retrieve the chemical and store it in the proper location. Return the bucket to the same location under the wall, this is just for passing chemicals into and out of the clean room, chemicals are not to be left in the buckets for more than the time it takes to enter the clean room and place the chemical in the proper storage location.

2. Gas

- a) All gases bottles over 25 lbs. must be transported with the gas bottle dolly with a proper restraining belt to secure to the bottle to the dolly.
- b) The bottle must have the cap tightly in place
- c) The gas bottle must conform to the CGA standards for fittings.
- d) The bottle must be properly secured with a restraining belt or chain when it is removed from the dolly.

- e) All gases pressurized above 100psi must have a pressure regulation mechanism to avoid over pressurization of the equipment during usage.

- f) Some gases may require flow restrictors in addition to a regulator.
- g) All gas bottles must be approved by the lab manger before they are brought into the lab.
- h) All gas bottles not in use (new or empty) are to be stored in the ECE courtyard gas bottle storage area.

3. Solids

- a) All solids chemicals are to be transported into the Clean Room from the storage bunkers by use of a transport bucket. The bucket will hold >125% of the chemical and be compatible with the chemical being transported.
- b) The bucket with the chemical will be placed next to the Clean Room wall just on the outside of the Clean Room so that it can be easily retrieved inside the Clean Room.
- c) After the bucket is placed outside the wall, go into the Clean Room and retrieve the chemical and store it in the proper location. Return the bucket to the same location under the wall, this is just for passing chemicals into and out of the clean room, chemicals are not to be left in the buckets for more than the time it takes to enter the clean room and place the chemical in the proper storage location..

H. Empty Bottles

1. Liquid

- a) If the bottle contents can be poured into the Acid Waste Neutralization system, then follow the steps below.
 - (1) Empty bottles are to be rinsed out in a sink 3 times.
 - (2) Put a small piece of pH paper (about 1 inch) into the bottle, if the paper shows a pH between 6 to 8, then you can dispose of bottle into the trash.
 - (3) If the pH is not between 6 to 8 repeat the rinse and then pH paper.
 - (4) If the bottle is to be used for a bottle waste and save the empty bottle for future reclaimed chemicals.

2. Gas

- a) The bottle should be left in place until a replacement bottle is delivered.
- b) If there is no need to replace a bottle, the bottle should be transported to the gas bottle storage area (cage in courtyard) for return to service provider.

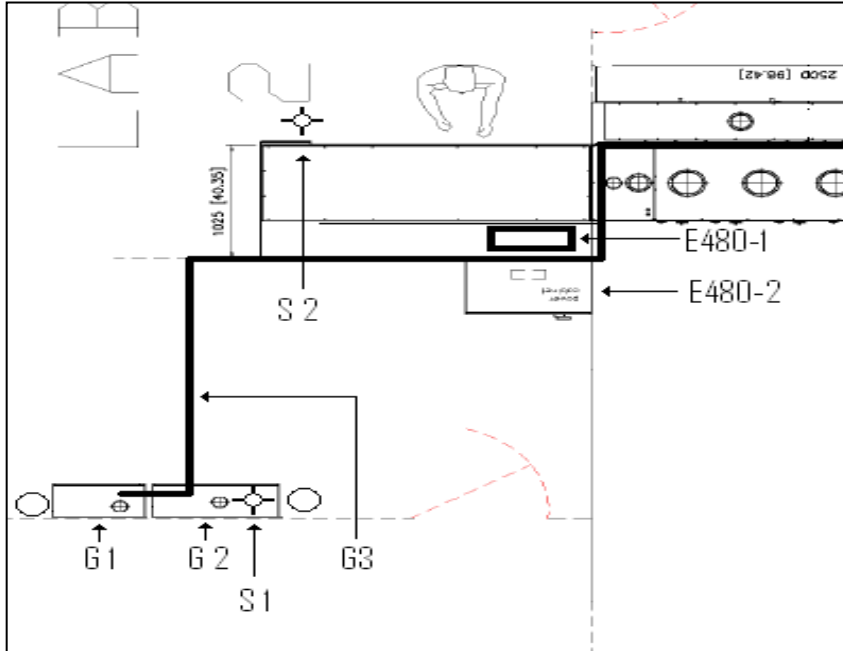
I. Cryogenic Liquids

- 1. PPE- Use the PPE as defined in Section II, passage D
- 2. Support –Cryogenic liquids are ordered through UA Cryogenics Lab.

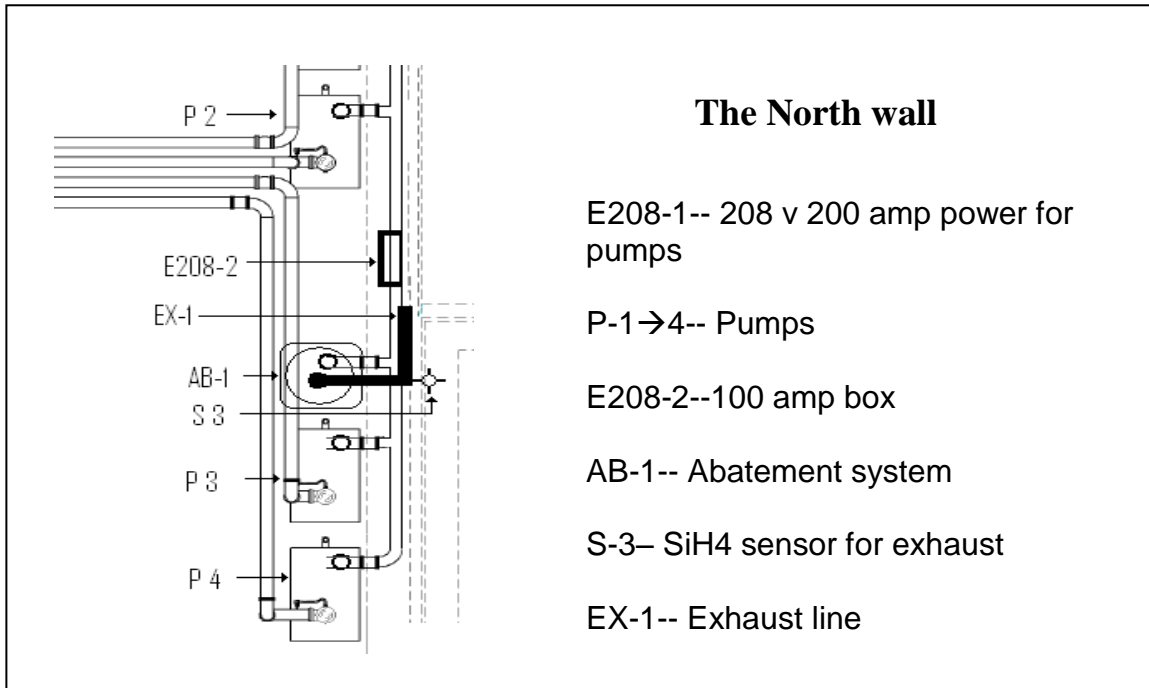
IV. The LPCVD system

A. Layout of the LPCVD tool:

Top View of the clean room and Chase



- G1- O2 & NH3 Cabinet
- G2- SiH4, Ph3/SiH4 & DCS Cabinet
- G3- Gas Lines
- S1 & S2- SiH4 sensors
- E480-1- Main 480 v Box
- E480-2- Main System Power Cabinet



The North wall

- E208-1-- 208 v 200 amp power for pumps
- P-1→4-- Pumps
- E208-2--100 amp box
- AB-1-- Abatement system
- S-3-- SiH4 sensor for exhaust
- EX-1-- Exhaust line

B. Gas used in LPCVD and Toxic:

1. The MSDS are on line with both the MFC web site and the gas vendors web sites.

	Pyrophoric	Highly Toxic	Toxic	Corrosive	LC (50) 1 hour rat (ppm)	Source:
SiH4	X		X		20,000	http://www.airproducts.com/MSDS
PH3 (15% in SiH4)	X	X			20	http://www.airproducts.com/MSDS
DCS	X		X		314	http://www.airproducts.com/MSDS
NH3				X	7,738	http://www.airproducts.com/MSDS
Oxygen					No data	http://www.airproducts.com/MSDS
Nitrogen					No data	http://www.airproducts.com/MSDS

C. Process gas (for a general process):

- a) N2 purge
2. Silicon Nitride DCS & NH3
 3. P doped SiO2 PH3 (15%)/SiH4, SiH4, O2 & N2
 4. SiO2 SiH4, O2 & N2
 5. Poly Silicon SiH4

D. Gas Cabinet

1. **NO** one is to open, touch, or even go near the gas cabinets without approval from the Lab manager. **Anyone** found working on the gas cabinets without proper approval will be ejected and banned from the lab.
2. The gas cabinets meet all of the requirements of the University safety procedures.
 - a) Self closing door/ports
 - b) Exhausted with > 200 fpm velocity
 - c) 12 gauge steel
 - d) Negative Pressure (exhaust) interlocked to shutdown flow and give an alarm
3. Restricted Flow Orifices are used on SiH4 & PH3/SiH4. They will not work with DCS.

		Pressures	RFO / Flow Rate in SLPM (Peak)
Gas	Specific Gravity	PSIG	0.006 " (RFO size)
SiH4	1.12	1200	16.44 (max flow in SLPM)
15% PH3/SiH4	1.1305	1200	16.36 (max flow in SLPM)

V. Tools

A. Process tools

1. The **1st Goal is Safety**: Safe persons, safe tools.
2. Use the tool for the purpose of which it was intended! If process is not to the defined process spec (Standard use is defined as using the tool as defined in the Operations Specification manual, which can be found on-line at <http://mfc.engr.arizona.edu/equipment.html>), then you must follow the next set of operating instructions:
 - a) All non-standard processing must have a detail work flow document. This document is to include all actions, chemicals, tools in order of use and the methods of use.
 - b) All non-standard processing must be approved by MFC staff before work is to be started. The detailed work flow document must be signed off by MFC staff.
 - c) For chemicals
 - (1) Source of chemicals.
 - (2) Are the MSDS on file with MFC and/or on the MFC website? Where and how are the chemicals to be used?
 - (3) Where and how are the chemicals to be mixed, and which containers are to be used?
 - (4) All mixing instructions.
 - (5) Process time and temperature.
 - (6) Waste stream and proper use of the waste stream.
 - d) For tools, any changes to the standard use of the tool? (Standard use is defined as using the tool as defined in the Operations Specification on line at <http://mfc.engr.arizona.edu/equipment.html>).
3. Do not operate any tools unless you have been trained by MFC personnel or other approved persons.
4. All covers and panels must be place properly on equipment.
5. Do not modify the any tools.
6. You may adjust a normal setting as defined in the tool training manual or within the tool spec on MFC website.
7. You must log onto the tool log at the beginning of your work, and log off when you complete your work.
8. If you find a problem with the tool, document the problem in the log and call the MFC staff to report the problem.

B. Hand tools

- a) Students with Clean Room or Chase access may use the maintenance shop, if the project is to be used in the Clean Room or Chase of ECE 213.
- b) All supplies are provided by the student or there research group.

- c) Shop tool can be used, as long as tools are used correctly and kept in the condition in which you received it. All tools should be returned to the machine shop and should only be used for the purpose for which they are intended.
- d) If a student does not follow the rules, they will not be permitted to use the shop.
- e) Proper PPE must be used, (including safety glasses!).
- f) Closed toe shoes are to be worn when working in the Clean Room or Chase, **NO** opened toe shoes can be worn, i.e., sandals or flip flops.
- g) No student work is to be left in the machine shop. You must not leave your project unattended and remain in the area at all times until you are finished. You must clean up the area after you are finished with small research related projects.

VI. Conduct

- A. Training-- Do not operate any tools unless you have been trained by MFC personnel or persons designated by MFC as being qualified operators of the equipment of interest.
- B. Dress code:
 - 1. Must be appropriate for work being performed and for conditions you may encounter.
 - 2. Must not wear loose sleeves shirts, ties, lapels, shirts with cuffs, or loose clothing near moving machinery or tools.
 - 3. In the Clean Room, clothing should be of a non-shedding, closely weave material.
 - 4. Shoes that completely cover your feet must be worn at all times in the Clean Room and the heel may be not more than 1” inch thick.
 - 5. Shorts and skirts may be worn in the Chase area (unless you are working with chemicals), but not in the Clean Room.
- C. Music
 - 1. Personal music systems (with headphones) may be used in the Chase area, only if you can clearly here a normal conversation.
 - 2. Personal music systems (with headphones) may not be used in the Clean Room.
 - 3. Approved radio (or recorder music players) may be used in the Chase, Clean Room or other work area, only if:
 - a) The volume is low and does not inhibit normal conversation.
 - b) If anyone in the area objects to the music, then it must be stopped.
 - c) At any time an emergency communication is announced, the lab user must be able to clearly hear and understand what’s communicated, whether it’s an alarm or voice communicated message.
- D. Limited access—Different users have different levels of access, based on time of day, or room. Please respect this access, if you do not, you may have your access limited or removed.
- E. Horseplay—the labs are for research or education, other actions or rough housing will not be tolerated. Horseplay in the Clean Room or Chase can not only cause accidents, but put important tools and lab user projects in jeopardy.

F. Logbooks and computer logging—Logging into the change room log and on each tool is required, if you do not log when in the change room or on a tool before use, you may have your access limited or removed. Logging in will also alert us that you are in the Clean Room, if an emergency should arise.

G. Access codes and key are issued to each individual receiving access to lab. You are not to give your access codes or keys to any other person. They must follow the same steps you did to receive access or keys. The type of access you receive is only for your personal use to access lab areas. If others are using your access, you could be liable for any accidents or safety hazards that occur during the time the individual is in the lab, and may have your access limited or removed.

H. Clean Room Gowning

1. In the gowning room, bags, coats, boxes, paper and any other non-essential material should be kept to an absolute minimum.
2. Items are not to be stored at any time in the gowning room, use the lockers outside along the hallway.
 - a) Hands should be clean and dry prior to entering the gowning room.
 - b) Shoes should be clean and dry must be enclosed shoes such as tennis or causal shoes. Sandals, flip flops, and high heels are prohibited.
 - c) Clothing should not be dirty or frayed. Any non-woven clothing is prohibited. Long pants or jeans are suitable attire. Skirts and shorts are not permitted in the Clean Room.
 - d) Contact lenses are prohibited. Prescription eye glasses are acceptable, but must be worn under safety glasses.
3. The gowning procedure and sequence:
 - a) On the outside of the clean room area in the change room put on:
 - (1) Hair net must be worn under lab hood.
 - (2) Shoe covers (booties) go over your shoes. (Please reuse the hair nets and shoe covers as much as you can)
 - b) Next move inside the clean part of the change room put on your:
 - (1) Hoods (use the snaps on the hood to ensure a snug fit around the head)
 - (2) Coverall must be worn over personal clothing at all times.
 - (3) Clean Room booties must be placed over shoes.
 - (4) Safety Glasses must be worn at all times.
 - (5) Clean Room gloves must be worn at all times.
4. The De-gowning procedures:
 - (1) Remove:
 - (a) Safety Glasses
 - (b) Clean Room booties
 - (c) Coveralls (take care not to have the coverall contact the floor)
 - (d) Hood
 - (e) Gloves
 - (2) If you will be visiting the Clean Room on a regular basis:

(a) Save time by hanging your overall on a hanger on the garment rack, then snap boots to the lower part of coverall and place your hood on the top of the coverall. Save hair cap for re-use by placing in the hood. (sign up for the hanger)

(3) If you will not be going back into the lab, place all the items you used into the laundry bag by the door and the used hair net and gloves in the trash.

(4) The goal of the lab is to reuse Clean Room items as often as possible. If after many uses, you feel you need a new, just replace as needed.

I. The following items are prohibited from entering in the Clean Room or Chase:

1. No food, including drinks, chewing gum, candy, etc.
2. Cardboard boxes
3. Tissue (i.e, "Kleenex")
4. Lighters or matches
5. Pencils – use ink pens only
6. Regular paper okay to use in Chase, but in Clean Room please use clean room paper.

VII. Evacuations

A. Scheduled, evacuations are scheduled from time to time, there will be scheduled evacuations of the Clean Room and Chase; for instance:

1. When other PM activities may impede safety
2. In the course of changing a gas bottle, or
3. During a gas bottle change there will be:
 - a) A "**Do Not Enter**" light will be at each common door way to Chase or Clean Room.
 - b) There will also be chains to block some areas of the lab during the bottle change
 - c) The Clean Room and Chase will be off limits to all persons not working on the bottle exchange.
 - d) Please "**DO NOT ENTER!**" during this time period; a normal bottle exchange should take about 1 hour.
4. All persons not taking part in the PM activities must leave both the Clean Room and the Chase.
5. We will post the time and day as soon as it is scheduled or when we know the bottle exchange will take place.

B. Un-Scheduled Evacuations (Full Area); if there is an Un-Scheduled evacuation based on a fire alarm or other safety issues, then you must leave the area as soon as possible to ensure your safety. Do not complete your work, you must **STOP** and **LEAVE** the area immediately.

C. Limited Evacuation; this is when lights or horn go into alert mode at the gas cabinet or in the Clean Room near the LPCVD tool, if the .5 TLV level is crossed.

- a) If the **Blue flashing light (& horn)** goes off at the gas cabinet or the tool work area, **leave the area at once**, and immediately contact the MFC staff.

b) This is a local evacuation only; leave the area or the proximity area of 25 feet from the sounding alarm.

D. Relocation point— if there is an evacuation all persons in the Clean Room or Chase are to leave the area existing through the south west door and meet others outside next to the bike rack.

VIII. When something goes wrong!

A Broken tools

1. Ensure that there is no longer any danger to the tool, users or product.
2. Complete you work, if you can without adding additional harm or damage to tool.
3. Log the tool information down on the tool log and give as much details describing the problem, then contact the MFC staff and report the problem.

B. Broken glassware/wafer or other sharp instruments

1. Broken glassware, wafers or other sharp items are to be placed in the Sharp Box in the Chase next to the LPCVD tool.
2. Ensure that the glassware, wafers or other sharp items are at room temperature and free of chemicals before disposing.

C. Chemical spills

1. If you can stop the source of the spill without putting yourself in jeopardy, do so.
2. Evacuate the area, asking all others in lab to evacuate the area, and then contact the MFC staff and report immediately.
3. If after hours, use the spill kit to contain the spill or spill pillows to adsorb the chemical. The spill kit and pillows are keep (in small amounts) in the small Chase between photo bay & LPCVD. There are more spill items in the back room at the west end of the machine shop. Contact lab manager by cell phone.
4. Spill socks and pillows should then be placed in a trash bag (bags can be found with the spill kits) and fully marked with the name or identity of the chemical spilled.
5. If a spill happens after normal hours use the cell phone numbers and contact MFC staff immediately to receive assistance and to report spill.
6. Remember to document the spill and clean up, a report will need to be completed after the spill clean up and MFC staff will conduct the interviews to determine if safety procedures were followed and if re-training is needed.

D. Personal Accident; if a person is hurt, they are to be given first aid immediately following the incident, if the accident is of major concern, then you must contact UA police or 911. Following the safety of the person or persons, a report will be completed and MFC staff will conduct the interviews to determine if safety procedures were followed and if re-training is needed.

E. First Aid kits; are located in the Chase by the northwest doors and the southwest doors. The machine shop has a kit to the right of the door as you enter the Chase, and the Grad student office has a kit to the left of the door as you enter the office. There is also a kit in the Clean Room in the photo area.

F. Emergency Response Guide (posted around the area)

G. Paper work— If an accident, spill or emergency occurs in the lab, you will need to completed a report with the MFC staff, who will conduct interviews and complete and process the report and pass on to Risk Management. All users must follow protocol should an accident in lab occur.

H. Emergency Response Team (ERT)

1. MFC has put into action an ERT team for the lab.
2. Gregg Cure' is the team leader.
3. Follow all safety instructions from the team or the team leader

I. Abatement System (for LPCVD tool)

1. A Centrotherm Dry Resin canister for Gas Abatement System is used on the output end of the pumps.
2. This system will:
 - a) React & Remove SiH₄, DCS, NH₃ & PH₃
 - b) All 4 gases should be at or near the TLV before going into the exhaust, in the house exhaust system, the tool exhaust will be mixed with the house exhaust (about 300,000,000 sccm) before it is released to the air.
3. Sensor on the output of the Abatement System will be set to about 2X TLV for SiH₄, this will be used to tell us when we need to change the abatement system

IX. HF can be used safely. It is used in large quantities for industrial applications and in commercial labs. HF requires a healthy respect, good lab practices, and appropriate safety precautions.

1. Set up in a working hood, never anywhere else!
2. Set up your workspace carefully. Get everything out of your workspace that you do not need. Clutter can result in accidents.
3. Wear a lab chemical apron, rubber gloves (not just the vinyl gloves), including goggles or a face shield. Check gloves for tears or holes.
4. Take special care with pipettes, beakers and work surfaces since they may produce spatter or drips.
5. Be sure the HF 'antidote' Calcium Gluconate Gel cream is handy. Check the cream expiration date.
6. Review where you can go to quickly wash off spilled HF. Be sure there is nothing obstructing the sinks or the lab shower. Do not worry about the lab shower making a mess that is what it is for.
7. Keep the hood sash as low as is convenient for your work.
8. When finished, clean up your area and put everything away. Put anything contaminated with HF in the back of the hood and wash it completely, if the items can not be washed (paper towels) then it needs to go into a plastic bag and tag as waste it should be marked for waste removal and place in the waste holding area, in the water room. Any member of the MFC staff can show you were this area is.
 - a) Mark the bag with one of the tags supplied by the lab. Fill in all information requested on the tag.
9. Dispose of used HF properly.

X. Contact us

- **Omid Mahdavi**, omidm@email.arizona.edu, Facility Supervisor, (520) 621-9849
 - **Gregg Cure**, gcure@ece.arizona.edu, Maintenance Supervisor, (520) 626-1987
 - **Pat Rodriguez**, prodrigu@ece.arizona.edu, Administrative Associate, (520) 626-1524
1. If you have questions on how to do something or use tools or equipment, PLEASE ASK!
 2. Always fill out the equipment log.
 3. If a tool is not working properly, do not try and fix it, please report it immediately to the MFC Staff!