Knowledge Enterprise Development

Arizona State University

NanoFab Safety Handbook 2025

Rules and Procedures 2025

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NanoFab Directory 2025

Staff	Phone	Office	Email
Chao Wang, Governance Board Chair	965-2056	ERC 539	Wangch@asu.edu
Kevin Hilgers, Director of Operations	965-5256	ERC 153	Kevin.Hilgers@asu.edu
Art Handugan, Equipment Engineer	727-7143	ERC 151	handugan@asu.edu
Kevin Nordquist, Process Engineer	965-3410	ERC 144	Kevin.Nordquist@asu.edu
Scott Ageno, Process Engineer	727-7383	ERC 144	Scott.Ageno@asu.edu
Carrie Sinclair, Engineer Assoc	965-9143	ERC 144	carrie.sinclair@asu.edu
Jaime Quintero, Process Engineer	965-2675	ERC 144	Jaime.Quintero@asu.edu

Facilities	Phone	Room
NanoFab User Storage		ERC 127
FESEM Support Lab		ERC 129
FESEM Lab		ERC 131
EBL Lab		ERC 133
Special Processing Lab		ERC 138
Cleanroom	965-7876	ERC 146
Probe Stations		ERC 240

Section I. Collective Commitment to Safety

We must all be committed to maintaining a safe working environment: ***"No research is so important that it justifies endangering human health"*** (to quote from a College [now renamed the Ira A. Fulton School of Engineering] safety memo dated June 16, 1986). We must all be vigilant. If you see something that does not look right, could be a hazard, etc. please report such concerns immediately to NanoFab staff. The NanoFab has made a serious commitment to become a role model in safety for the University. The ASU has safety officers to support and assist us with general environmental, health, and safety matters. Please feel free to contact NanoFab staff if you have any safety-related questions.

The Bottom Line on Safety

- ***Ignorance of the rules, lack of common sense, language difficulties, carelessness, and haste are not adequate excuses for unsafe behavior***
- ***In spite of rules and staff supervision, primary responsibility for safety rests with the individual user***
- ***If you do not have time to do things correctly and safely, with adequate time for thought, please stay home***

A. Basic Safety Orientation

The NanoFab requires that **prior to starting work** all users of the Cleanroom and associated laboratories attend:

1. The ASU Environmental Health & Safety (EHS) presentation on Laboratory Safety Training. Attendance at the ASU EHS safety class is a University policy requirement for anyone operating in a laboratory environment.

2. Fire Safety Annual training, also presented by ASU EHS. This annual training is an ASU requirement.

3. Hazardous Waste Management training presented by ASU EH&S. This annual training is an ASU requirement.

4. Hydrofluoric Acid Safety Training. This annual training is necessary since HF acid is used in the Cleanroom, even if the user is not specifically processing with it.

Each user may require different training, so the training determination tool will select safety training specific to your needs. ***https://ehstrainingtool.asu.edu/***

5. **The** NanoFab's internal "Cleanroom Safety Class" is mandatory and is typically offered bi-monthly. The Safety Class includes a written test in which a passing grade (80%) is required to gain access to the cleanroom and laboratories with chemical usage. Each person must obtain a copy of the current "NanoFab Safety Handbook" by downloading it from the ASU Nanofab website (https://cores.research.asu.edu/nanofabrication-and-cleanroom/get-started). There is a $350 fee to attend this class.

Individuals are further required to sign an agreement that they understand the NanoFab's safety guidelines and the consequences for non-compliance (i.e. penalties). These classes serve only as an introduction to safety. Students, faculty and staff are encouraged to continue their education at every opportunity.

Examples:

- Attend EHS Refresher Training
- Review MSDS of the chemicals you use
- Check vendor websites for updates
- Join SESHA, the Semiconductor Environmental Safety & Health Association.

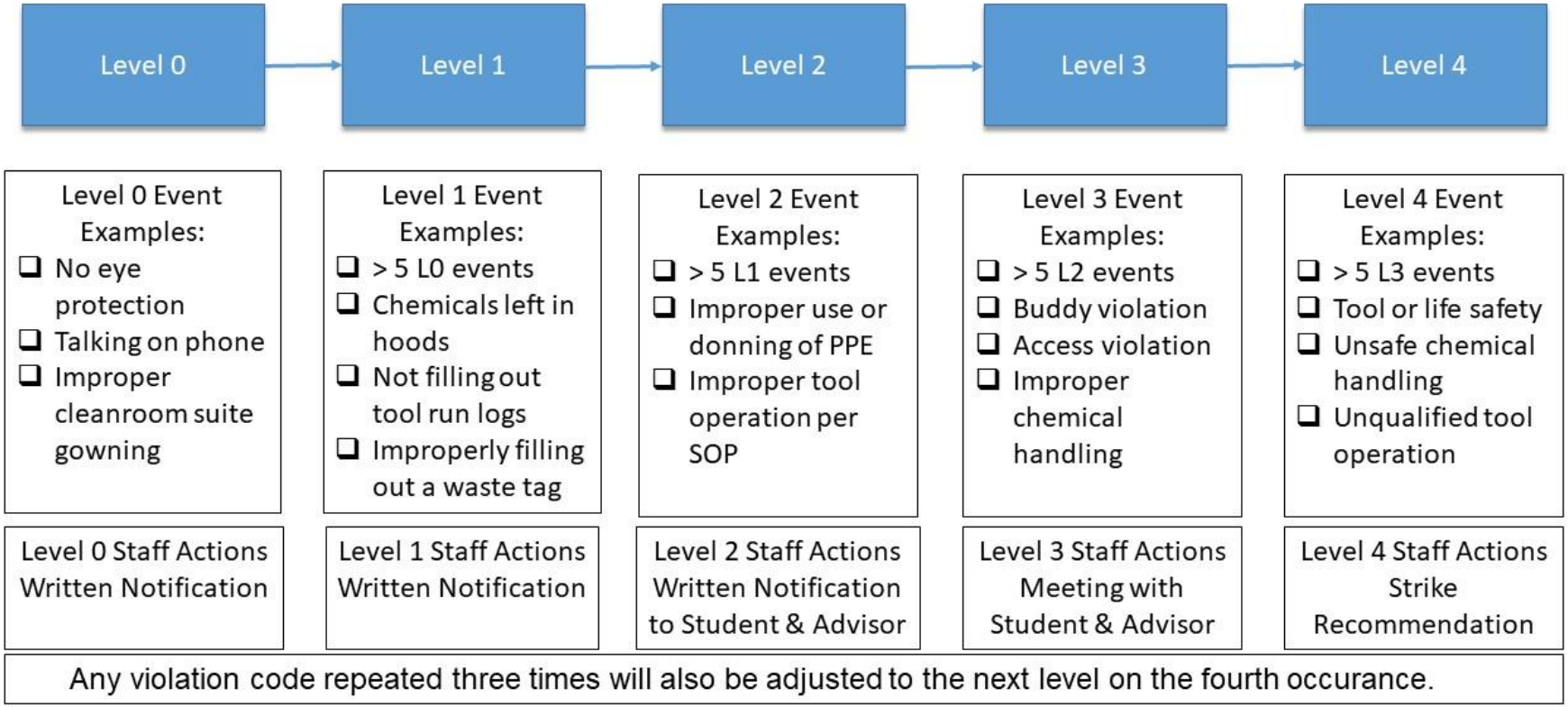
B. Penalties

Article Three (Policies and Operations), section 1 of NanoFab's Bylaws? articulates the following; "Maintenance of a safe, collegial and pleasant working environment for faculty, staff and students is the primary responsibility of the NanoFabDirector of Operations and the staff." It is the intent of this document to encourage an attitude commensurate with this goal. However, the NanoFab must have an effective method of recourse to discourage unsafe actions and penalize repeat offenders. Industry does not tolerate safety and environmental infractions: you are simply fired.

The NanoFab's Governance Board have approved a 2-Strikes Policy with offenders in regards to matters of safety, hazardous chemical handling, waste, and disposal. Acts of criminal behavior will result in expulsion and/or termination. Criminal behavior is deliberate and willful disregard for safety procedures that results in a hazard to personnel, equipment, or facilities. Criminal acts will result in legal as well as disciplinary action.

We describe our day-to-day (actual current practice) uniform application of rules and procedures, including escalation toward a strike recommendation for major safety infraction. A strike can also result from repeated disregard to prior instructional safety warnings. One of our goals is to better educate users in matters of safety so that everyone will have a pleasant experience in the facility therefore, the NanoFab's Governance Board have approved a Violation Escalation Policy. The following diagram illustrates the violation ranking level and required actions by the NanoFab staff and Governance Board. A list of known violations and level assignment is available to all NanoFab users upon request.

NanoFab Safety Violation Procedures



1. For Level 0 violations, a verbal warning by the staff member will be documented in the NanoFab Safety folder by name, nature of infraction, and when it took place making the observation along with any mitigating or aggravating circumstances. For the most part, these warnings are simple reminders to follow rules and procedures. No remedial action is taken since the purpose is to reinforce instructional value.

2. After three of the same violation or five unrelated violations on any Level causes the subsequent violation to be raised to the next Level event.

3. Any Level 1 violation will result in a written warning to the individual and the NanoFab Staff.

4. Level 2 violations result in written warnings and constitute a more serious disregard of rules and procedures and will be forwarded to the individual, their faculty/supervisor and NanoFab staff. ACTION is EXPECTED from the individual to remedy the infraction. For example, leaving waste chemicals in the pass-thru for an extended period of time is not allowed: The corrective action would be to remove them to the waste cabinets as soon as possible.

5. Level 3 violations require a meeting with the individual, their faculty/supervisor and NanoFab staff.

6. A Level 4 violation results in an immediate strike recommendation. If a NanoFab staff member believes there has been a serious violation of the rules and procedure on an individual's part, the staff is authorized to ask the individual to leave the facility immediately and shall report the incident to the NanoFab Director of Operations. Please be respectful and courteous should you be asked to leave the facility: Please do not be contentious. We will discuss the matter calmly afterwards. The NanoFab Director of Operations shall notify the NanoFab Governance Board, OKED Safety Officer and the individual's faculty advisor in writing for strike recommendation meeting.

    a. **First Strike:** Access to all NanoFab equipment and labs shall be revoked until the individual and his/her advisor meets with the NanoFab Director (or designee) to discuss the circumstance of the violation. ASU EHS may also be invited for assistance. The strike recommendation committee may require the individual write a personal improvement plan to be approved by NanoFab.

    b. **Second Strike:** Access to all NanoFab equipment and labs shall be permanently revoked following recommendation by the Governance Board (as serious threat to maintaining a safe working environment within the NanoFab). Further penalties may be imposed to fit the severity of the violation. This may result in financial penalties, termination of academic program with NanoFab/ASU and/or employment termination procedures with ASU.

C. Safety Links

This safety document has been prepared by NanoFab members (faculty, staff, and students) and representatives from the ASU Environmental Health & Safety (EHS) Department. The document outlines the current chemical handling procedures and policies regarding safety within the NanoFab. This original document was enacted on 6/1/1998. Revisions and updates of this document will occur on a periodic basis.

If there is a conflict between NanoFab's guidelines and those of the University, the University rules shall prevail.

Please also visit the ASU web sites below for more detailed information on hazardous waste management policies:

The University Environmental Health & Safety (EHS) homepage can be found at:

https://cfo.asu.edu/ehs

Please also visit the web-site below for Incident Report forms, links to Safety Data Sheets (SDS/MSDS's), hazardous waste pick-up requests, responsible party information and other safety-related topics.

https://cfo.asu.edu/ehs-assistant

or

https://cems.unh.edu/asu/CEMS/Dashboard

How to submit an online hazardous waste pick-up request.
https://cfo.asu.edu/waste-mgmt-and-shipping
or
https://cems.unh.edu/asu/CEMS/Dashboard

Section II. Cleanroom Protocols

Note: Rules are shown in Bold *Procedures and FYI's are italicized*

It is important that a uniform safety code exists throughout NanoFab. The Cleanroom protocols outlined below apply to all of NanoFab laboratories with chemical usage. These shared and dedicated laboratories include: ERC133, and ERC138. Hazardous waste (by regulatory code) must be contained in the laboratory in which it is generated. Disposal of waste is handled by ASU EHS. Submit an online waste pick-up request at https://cems.unh.edu/asu/CEMS/Dashboard.

Users must apply for ISAAC access to ERC146A (chemical waste cabinets) and ERC146C (hallway door) in order to properly participate in NanoFab's hazardous waste management plan.

A. General Cleanroom Guidelines & Rules

1. **Do not work in the Cleanroom if you feel particularly tired or unwell (e.g., heavy cold or allergies) or if you have taken even a small amount of medication or alcohol.**

2. **All personnel must wear safety glasses or goggles while they are in the Cleanroom. Contact lenses are not allowed in the Cleanroom.**

3. **Always use the 'NanoFab Buddy System' when working in the Cleanroom after normal working hours, which are: Monday – Friday, 8AM – 5PM. Do not work alone outside of these hours.**

    a. **"Buddy-1"** applies to the Cleanroom, ERC138and Liquid Nitrogen fills: Compulsory buddy system applies for outside of normal working hours. Buddies must be valid users of the cleanroom.

    b. **"Buddy-2"** will apply to, ERC129, ERC131, and ERC133. The Buddy-2 'collegial' advisory is as follows: Outside of normal working hours we strongly recommend you inform an associate or colleague: of your whereabouts; what you plan to do; how long it will take you; etc. The Buddy-2 support person can be located anywhere on campus. The key point is that if the support person doesn't see you or hear from you in a while, e.g. you are long overdue, the expectation is that the support person would follow up to see if anything is amiss. We also suggest periodic lab check-ups during the course of any extended off-hours research activity. We have clearly identified those NanoFab laboratories deemed "Buddy-2" with signs on the doors to aid your recognition of the Buddy-2 system.

4. **Personal cleanliness is essential for any cleanroom environment. Makeup, of <u>any type</u>, is forbidden in the cleanroom.**

5. **No dangling jewelry is to be worn in the cleanroom.**

6. **For SAFETY reasons, shorts or bare midriffs are not allowed in the cleanroom.**

7. **Shoes shall cover the entire foot with no open toes, sides, or heels and must be worn when handling or disposing of chemicals. No sandals, flip-flops, or high heels over 1.5".**

8. **No food or drink of any kind is allowed in the dressing area or the cleanroom. Food or drink includes such items as: candy, gum, cough drops, coffee, water, etc.**

9. **Smoking is is not allowed anywhere on the ASU campusper the Smoke-Free Arizona Act – Arizona Revised Statutes, Title 36 § 36-601.01.**

10. **Personal Protective Equipment (PPE) apparel must be worn when handling or disposing of hazardous chemicals. The minimum appropriate PPE for each class of chemical must be worn. This includes safety glasses or goggles, face shield, chemical gown, and chemical gloves and/or nitrile gloves.**

11. **All personal items such as backpacks, makeup, combs, brushes, handkerchiefs, hats, electronics, etc. are not to be brought into the clean room or the dressing area.**

12. **Only clean room paper and lab wipes will be brought into and used in the clean room. Notebooks, specifications, memos, schematics, magazines, or any form of correspondence are not to enter the clean room area unless they are laminated, in plastic covers, or on authorized clean room paper.**

13. **For SAFETY reasons, do not sit on worktables or lean on wet benches or equipment.**

14. **No spray cans or powdered materials are allowed in the clean room or dressing area.**

15. **No cardboard boxes or packaged materials are to be brought into the clean room.**

16. **Any debris on the floor or at a workstation is to be picked up and disposed of. Assume the responsibility for a clean, neat and safe work environment.**

17. **Due to the potential hazards of residual gases and other chemicals in tools, if a tool malfunctions while you are using it you must complete a online iLab Service Request, flip the tool status sign to the "DOWN" position and contact a Staff member.**

18. **Each user will be responsible for correct disposal of all hazardous waste as stated in Section VI. Storage of hazardous waste in the Cleanroom is NOT permitted. All hazardous waste chemical bottles MUST have a properly completed hazardous waste tag attached and moved into the appropriate chemical waste cabinet in ERC146A by the end of the day.**

19. **NanoFab electroninc device usage:**
    a. **Voice calls on cell phones only allowed in gowning room**
    b. **No electronic device usage when operating tools or using PPE**
    c. **No earbud usage with any electronic device**
    d. **Tablet usage allowed with the same guidelines as cell phones**

20. **Individuals are strongly encouraged to advise/caution/educate other facility users who are not complying with safety guidelines and protocols. Please report the individual/incident to NanoFab staff if the person continues to act in an unsafe manner.**

21. **Chemicals (in glassware or original bottles) are not to be stored in wet benches. Squirt bottles of approved common solvents are permitted in solvent benches. Users who need to run long or unattended wet chemistry experiments are required to obtain prior approval in writing from a NanoFab Staff member. Please send an email to all NanoFab Staff with your request. These experiments must be clearly marked and labeled, i.e. state the nature of chemicals, the user name, a contact phone number, and date and time experiment will be completed. NanoFab staff will dispose of unapproved experiments. All individual user (custom) chemical bottles must have the same appropriate labeling. All beakers, samples, bottles, etc. will be removed at the end of the normal workday.**

22. **Acids and other hazardous chemicals must be transported safely. To transport hazardous chemicals, the use of a rubber transport bucket" is mandatory. Transport carts are available in the "Acids and Oxidizers" pass-thru as an alternative to transport buckets.**

23. **Users must clean & dry wet benches after their work is completed.**

B. Cleanroom Clothing Guidelines

1. **Everyone entering the clean room will be required to wear an appropriate clean room garment. The apparel will include: face mask, hair net, hood, cover-all (bunny suit), boots, safety glasses or goggles, and disposable nitrile gloves.**

2. **Prior to gowning in a cleanroom attire, the user must first be wearing long pants; no shorts or skirts. If the user is not wearing long pants, they will be asked to leave.**

3. **Clean room attire will be put on in the following order: face mask, hair net, hood, bunny suit, boots, nitrile gloves. The attire is to be removed in reverse order: Nitrile gloves, safety glasses or goggles, boots, bunny suit, hood, Hair net and face mask. The clean room garment is to completely zipped up to the neck and the snap used to secure the collar area. The glove cuffs are to be placed over the garment sleeve cuffs and secured around the wrist. No street clothing is to be visible outside the clean room garment.**

4. **Boots must cover the shoes and have the legs of the bunny suit tucked inside the booties.**

5. **All hair must be tucked inside the hair net and the flap of the hood must be completely inside the bunny suit.**

6. **Clean room garments are to remain completely zipped up while in the clean room.**

7. **Clean room attire is not to be worn in a non-clean room area except in an emergency. The garments are to be stored in the dressing area on a hanger and hung on the rack.**

8. **Clean room garments are to be changed once a week. If the garment becomes damaged or badly soiled, then it should be changed immediately.**

9. **Shoes must be closed-toed should be clean and free of dried mud, dirt, etc. before entering the dressing area.**

10. **Do not touch your face, nose, mouth, or bare skin area while wearing the gloves in the clean room. This would introduce contamination to the product and/or the equipment.**

Standard Cleanroom Garment

C. MSDS Information

1. **All users must read the MSDS thoroughly and understand the properties and hazards associated with using or mixing chemicals.**

2. MSDS's are available for all chemicals used within the NanoFab cleanroom and its labs. They are located in the following areas:

    a. Master copy: Located in ERC144
    b. C/R copy: Located in ERC146A Chemical waste storage area.
    c. Labs: Only the chemicals which are approved, stored and used regularly in these labs have an MSDS located within.

D. NanoFab Provided Chemicals

1. NanoFab will provide the following general use chemicals. Please refer to Appendix B for proper (IUPAC) names of these materials.

Acetone	Hydrogen Peroxide
Isopropanol	Ammonium Hydroxide
Methanol	Acetic Acid
Hexamethyldisilazane (HMDS)	Nitric Acid
AZ 3312 Resist	Hydrochloric Acid
AZ 4330 Resist	Phosphoric Acid
AZ 300 MIF Developer	10:1 Buffered Oxide Etch (BOE)
AZ 400K Developer	Hydrofluoric Acid
AZ 400T Stripper	Sulfuric Acid
LOR 10A	Chrome Etch

2. NanoFab will provide the following chemicals for Electron Beam Lithography (EBL) use only:

Anisole	
	Methyl Isobutyl Ketone (MIBK)
2-Ethoxyethanol	Polymethylmethacrylate (PMMA)

3. The following chemicals **are not** provided by NanoFab but are approved for general use, i.e., no PHA is required to use them as long as the user has taken the NanoFab Safety Training:

AZ 4620 resist	AZ 5214-E IR resist
SU-8 Series resist	AZ 1505 resist
SU-8 Developer	Microstrip 2001 stripper
ZEP 520A resist	ZEP developer
maN-2403 resist	SF-6S resist
nLOF 2000 series resists	o-Xylene

4. **Absolutely NO chemicals are to be taken into or transported out of the NanoFab facility (cleanroom, ancillary labs, or chemical storage/waste rooms) without prior and written approval of NanoFab staff. Please consult a NanoFab staff member if you have any questions.**

5. **Gases**

    a. **A PHA must be submitted for all gas cylinders to be used in a lab, regardless of the cylinder size. An MSDS for each gas must be submitted with the PHA.**
    b. **The PHA must be submitted and approval granted prior to the gas being purchased.**

c. **All flammable, corrosive, or toxic gases must be contained in an approved exhausted/ventilated gas cabinet with all appropriate safety interlocks and sensors installed and operating.**
d. **Failure to comply with these guidelines will result in loss of access to the lab and /or all NanoFab facilities.**

Note: Additional safety or regulatory requirements may need to be met before approval.

E. Procedure for Ordering Chemicals for Usage in the NanoFab

The process for requesting new chemicals and chemicals that are not normally supplied and will be used in the NanoFab is as follows:

1. Determine if the chemical is currently supplied by the NanoFab. The chemical list is found in the Section II Subsection D above.

2. If the chemical is not supplied by the NanoFab, please submit a service request in iLab for the chemical. In the iLab chemical order request, please specify the desired quantity, chemical name, chemical formula, and supplier.

3. The NanoFab Safety Compliance Officer will then determine if a PHA is required. If required, NanoFab personnel will work with the researcher to have the PHA form filled out and the appropriate MSDS obtained from the manufacturer/vendor.

4. If approved for purchase the NanoFab will obtain a quote for the chemical. The quoted dollar amount will be reflected in the iLab service request for you to approve. Any additional costs, such as shipping, will be transferred to the requestor. There will be no charges for NanoFab personnel time.

5. Once the requestor has approved the quoted amount, NanoFab Staff will order the chemical, provide details of the delivery, and notify the requestor when it has arrived. Once the chemical has been delivered to the NanoFab, the chemical will remain in the NanoFab.

This process eliminates paperwork, delivery issues, and allows the NanoFab to purchase, store, and use the chemicals per the NanoFab's and ASU's safety and purchasing policies. The NanoFab is responsible for chemicals used and stored in the NanoFab. Therefore, standard cleanroom chemical usage and storage protocols defined in this Safety Handbook will be used and enforced by the NanoFab Staff.

For questions or problems with iLab chemical purchase requests please contact: NanoFab@ASU.edu

F. Preliminary Hazard Assessment

The purpose of the Preliminary Hazard Assessment (PHA):

1. It provides lab-specific accountability for the chemicals used in NanoFab.

2. The exercise of writing this document is to ensure that the chemical user understands the hazards and has thought through the process he/she is planning. This is also a right-to-know step to ensure that all users of a chemical have reviewed the chemical MSDS and understand its properties and hazards.

   A. An original PHA is required:

      1. For chemicals that are new to NanoFab (refer to Section IID. 1, 2, and 3).
      2. For chemical mixes and processes that are new to NanoFab. (If in doubt, contact NanoFab Staff)

B. An amended PHA is necessary:

1. For chemicals and materials that someone else brought into NanoFab, and you now wish to use (at NanoFab discretion. You may be required to submit a new PHA)
2. To take ownership of chemicals from someone who is graduating or leaving
3. To join a project already in progress by your group as a co-experimenter
4. To add new or different chemicals to a PHA you have already completed
5. To change process details of a PHA you have already completed

Please attach another PHA to a copy of the original PHA form sheet describing the changes (people added, chemicals added, process changes, etc.), supply any needed MSDS, and make sure that all experimenters sign it before submittal of the form. There is no need to copy all of the original information onto a new sheet, but must be able to explain the process, chemicals, and hazards.

Users who require other chemicals are required to write a proposal called a Preliminary Hazard Assessment (or "PHA") for the use and disposal of the chemicals. The Preliminary Hazard Assessment form is available at *the "Safety" link on the https://cores.research.asu.edu/nanofab/get-started webpage*. Prior to ordering, the user is to include a step-by-step plan for the chemicals, including use quantity, frequency and location of use, tools used and chemical disposal, per the following steps:

1. *The user is to obtain the Material Safety Data Sheets (MSDS) sheets for the planned/proposed chemicals prior to ordering.*

2. *The user is to contact NanoFab Safety Personnel to discuss their plan for use and disposal of new chemicals. The user will be instructed to write their proposal and submit a PHA for approval to NanoFab Safety Personnel. The PHA will be discussed among NanoFab Safety Personnel. Once the PHA is discussed, the user will be notified of any changes, safety concerns, requirements, etc. to be made. If there are no issues or concerns, the user will be notified of approval by NanoFab Safety Personnel.*

3. *Upon receiving approval to use the chemicals, the user shall provide 3 copies of the MSDS to NanoFab Safety Personnel. It shall be the user responsibility to place the MSDS in the lab MSDS binder.*

Section III. Incidents and Accidents

1. *Incidents and Accidents:* *An "incident" is any event, large or small, that either causes or has the potential to cause personal injury or damage or loss of property/equipment. All incidents MUST be reported per ASU EHS-115 policy. An Incident Report form may be found and completed at* ***https://cfo.asu.edu/incident-reporting*****.** *Follow the instructions per EH&S.*

2. **If you or your experiments are involved in an incident as defined above, you must notify NanoFab staff and complete an EH&S incident report. Failure to complete an incident report will result in the loss of lab and/or cleanroom privileges per the violation policy.**

3. **If you are injured at work: No matter how minor the job related injury/illness or accident may seem, it must always be reported within 48 hours of the occurrence by calling (602) 542-WORK or 1-800-837-8583. Notify your supervisor: they must fill out an "Employer's Report of Injury" form (must be completed and returned to the Customer Service Center no later than 9 days after the occurrence**.

4. *Failure to report within those time frames can result in severe monetary fines, payable by your department. Prompt reporting will accelerate the processing of the claim and will avoid unnecessary delays or denial of possible benefits, and/or penalties.*

5. *You may report directly to ASU Student Health or Tempe St. Luke's emergency (1500 S. Mill Ave, Tempe) for initial treatment unless the injury/illness is serious or Student Health is not open. If the injury/illness is serious or Student Health is closed, you should call your primary care physician or report to the nearest emergency room. Incident reports and the Employer's Report of Injury must still be filed.*

⋆CLEANROOM EMERGENCY PHONE⋆

The Telephone dials directly to **DPS** and is to be used **ONLY** in case of an **EMERGENCY** within the **NanoFab Cleanroom.**

Please provide the following Response Information:

Address: **ASU/Main Campus**
551 East Tyler Mall
Tempe, AZ 85287-6206
Building: **#63 Engineering Research Center**
Room: **146 (NanoFab Cleanroom)**
Phone: **480 965 7703 (emergency phone)**
480 965 7876 (cleanroom phone)

Section IV. Classes of Chemicals and Special Hazards

Chemicals and Safety: General Cleanroom (Fab) Guidelines

In the Cleanroom, various types of safety equipment have been installed to provide you with the most practical protection possible. For your own sake, always use the appropriate PPE; it is provided with your well being in mind. If your PPE saves your eyes, or prevents a serious injury to you just once, it has been worth it. Good safety habits aren't just for you, but also for all other users. Be concerned for their safety as well as your own. If you see someone performing an UNSAFE act or not following safety regulations, make him/her aware of it. If someone does not take enough concern for him/herself, tell a NanoFab staff member. It is for your good as well as that of all other users.

A. Hazardous Materials Defined

We need to have an understanding of some basic terms and definitions.

1. Hazard: Source of Danger

    a. Toxicity: Capacity of a substance to harm (poisonous).
        i. Local Toxicity: Affects the part of the body it enters
        ii. Systemic Toxicity: Affects body organs regardless of the point of contact

2. Acute Exposure: Sudden, short.

3. Chronic Exposure: Long term

    a. The relationship between toxicity, exposure, and individual susceptibility can be expressed as Dose/Response.

4. Threshold Limit Value or TLV: The amount of a substance to which the one can safely be exposed to over a specified period of time (usually eight hours a day, forty hours per week).

5. Material Safety Data Sheet (MSDS) for each material/chemical will tell you everything about the material being used, including flammability, reactivity, toxicity, safety and treatment.

6. **The ASU Environmental Health & Safety (EHS) Lab Chemical Safety course must be completed as a requirement of the cleanroom orientation.**

B. Paths for Chemicals to Enter the Body

In order for us to have a good understanding of safe chemical handling, we need to understand the way chemicals enter the body and some safe guards to use to protect ourselves:

1. Inhalation -nose, mouth, most common way chemicals enter the body.
    - Prevention: Exhaust hood, respirator.

2. Absorption through the skin, cut, or wound.
    - Prevention: aprons, chemical gowns, rubber gloves, eye protection, approved footwear.

3. Ingestion- swallowing, also can be picked up from hands when eating, smoking, etc
    - Prevention- wash hands before eating or smoking.

4. Eyes- splashes, rubbing eyes with hands, etc.
    - Prevention: safety glasses, face shield, ventilation, exhaust.

5. Injection
    - Prevention: handle bottles carefully; be careful with sharp objects.

C. Personal Protective Equipment (PPE)

NanoFab provides all users who work in the Fab area protective clothing and equipment. It's important that you know how to use this equipment and how to care for it. Listed below is some of the equipment and rules to follow when using it:

- **Chemical resistant gloves**
- **Face Shields**
- **Safety Glasses and Goggles**
- **Chemical resistant gown**
- **Chemical Transport Bucket**

1. Any person working with acids, strong bases and/or solvents must wear safety gear.

2. Ensure proper fit; never alter or change protective clothing in any way and always wear it in the prescribed manner.

3. Inspect the gear before each use and test as necessary to ensure proper protection; remove from service if faulty.

    - Chemical Gloves:
        A. Check chemical gloves periodically.

        B. Gloves must be washed off with water and dried frequently, especially before removing them.

        C. Never touch gloves with bare hands, always remove them at the same time and handle by the cuff only.

Proper Gowning Procedures for PPE

	
1) Standard cleanroom garment.	2) Put chemical gown on.
	
3) Put on face shield. Don't touch face shield with chemical gloves.	4) Finish with chemical gloves. Notice transfer bucket..

D. Cleanroom Chemicals - General Safety Information

Class	Acid	Base	Oxidizers	Solvents
Major Hazard	Corrosive: pH <4	Corrosive: pH >9	Liberates Oxygen	Flammable, some are also toxic
Contact with skin/eyes will result in:	Chemical Burns			Irritation & possible absorption of toxic chemicals into body
Required PPE:	Safety Glasses or Goggles and Face Shield			Safety Glasses or Goggles (No contacts)
Eyes/Face		As a minimum, when using <100ml and no pouring or mixing will occur, nitrile gloves & safety glasses must be worn.		
Body	Chemical Gown			N/A
Hands	Chemical-Resistant Gloves			Solvent-Resistant Gloves
First Aid Steps	Rinse for 15 minutes with water using eyewash, shower, or if appropriate faucet (spill on hand or wrist); another user in room should contact NanoFab staff member. Serious or life threatening situations require calling 911 or ASU DPS immediately.			
	For HF contact, apply Calcium Gluconate to affected area. Refer to treatment of HF exposure for additional steps.			
	If any sensation (burning, itching) is noticed in affected area or if any chemical is splashed into eyes, go to Student Health or Tempe St. Lukes hospital.			
	Complete Incident Report: https://cfo.asu.edu/incident-reporting			
Handling	Read label and MSDS. Carry in chemical buckets			
Segregation	Keep separate from: Solvents & Bases	Keep separate from: Acids & Oxidizers	Keep separate from: Bases	Keep separate from: Acids
	Maintain HF separately			
Use	Read MSDS. Always open & use chemicals under fume hoods to minimize chemical inhalation			
	Always add acid to water			Mixing solvents may result in undesired reactions. Keep separate unless known to be compatible.
	Mixing acids may result in undesired reactions. Keep separate unless known to be compatible.			If unknown odor is noticed, contact NanoFab staff.
Storage	Acid/HF Cabinet	Corrosive/Base Cabinet	Corrosive/Acid Cabinet	Flammable/Solvent Cabinet
Spill Response	See Spill Response Chart, Section VII			
Disposal	No drain disposal of chemicals or waste.			
	Refer to Waste Disposal Procedures, Section VI			

Acids

Examples: Hydrofluoric, Nitric, Hydrochloric
Major Hazard: Corrosive. Will cause chemical burns to skin and eyes.

Characteristics:

1. Corrosive with a pH less than 6.
2. Usually non-flammable.
3. Soluble in water.
4. Will produce heat (burn) on contact with the moisture in your skin or eyes.

PPE: The corrosive nature of acids can result in serious, permanent damage to skin and eyes if contact is not prevented or controlled by PPE:

1. Eyes: Face shield AND Safety glasses or goggles
2. Hands: Acid Resistant Gloves
3. Body: Chemical Gown

Handling/Use/Storage:

1. Acid Hoods are Hoods # 1, 2, & 4.
2. Read and understand the MSDS for the selected acid.
3. Check labels to ensure correct acid was selected. Do not use chemicals that are not properly labeled.
4. Acids must be transported in chemical buckets.
5. Acids and solvents do not mix. Keep them separate. Do not use acids in a solvent hood.
6. Keep Hydrofluoric, Sulfuric, and Nitric Acid separate from other acids and from each other. Use secondary containment whenever possible.
7. The corrosive characteristics of acids extend to their vapors. Open acids only in an acid hood and do not place your head in the hood.
8. When handling acids, remember "**A. A. A. Always Add Acid to Water**".
9. Never add water to acid.
10. Acids are to be stored only in the marked acid cabinet. Bottles returned to storage must be tightly capped, rinsed off and wiped down.

Spills: The best spill plan is to prevent spills from occurring. Use containment buckets and pour and mix carefully. Extra precaution is required in crowded conditions and when visibility and dexterity may be impaired by PPE.

1. Should a small acid spill occur (< 100 ml), use a clean room wipe wetted with DI to wipe the spill.
2. Spills over 100 ml and up to 1 liter may require staff or EHS assistance.
3. Evacuate the clean room and Contact NanoFab staff or EHS (5-1823) for spills over 1 liter.

First Aid: Because acids are water soluble, immediately rinsing areas of skin or the eyes that have been contacted with an acid will reduce the severity of the damage.

1. Rinse area for 15 minutes.
2. Seek medical attention at Student Health or Tempe.
3. Complete incident report or detail incident to supervisor so they may complete incident report.

Waste: Pouring chemicals down a drain is a violation of federal law.

1. The person who uses the last remaining amount of chemical in a bottle must fill the empty bottle with 1L (1/4 gallon) of water and attach a hazardous waste tag and place in the chemical waste cabinet for EHS disposal.
2. Acid waste is to be collected in containers, placed in the acid chemical waste cabinet..
3. All vessels used for chemical processing will be rinsed three times with water and the rinse water will be captured in a waste bottle, tagged as hazardous waste, and placed in the acid chemical waste cabinet for EHS disposal.

Bases

Examples: Sodium Hydroxide, Ammonium Hydroxide, Some Developers and Photoresist strippers.
Major Hazard: Corrosive. Will cause chemical burns to skin and eyes.

Characteristics:

1. Corrosive with a pH greater than 8.
2. Usually non-combustible.
3. Will produce heat (burn) on contact with the moisture in your skin or eyes.

PPE: The corrosive nature of bases can result in serious, permanent damage to skin and eyes if contact is not prevented or controlled by PPE:

1. Eyes: Face shield AND Safety glasses or goggles
2. Hands: Chemical Resistant Gloves
3. Body: Chemical Gown
4. Small quantities: When using < 150 ml, and no pouring or mixing will occur, Nitrile gloves and safety glasses must be worn, as a minimum.

Handling/Use/Storage Procedures

1. Read and understand the MSDS of the base being used.
2. Check labels to ensure correct base was selected. Do not use chemicals that are not properly labeled.
3. Bases are to be transported using a chemical bucket.
4. Bases can react violently with acids and oxidizers. Keep them separate.
5. Base Bench/Hoods 6 & 7.
6. Bases are to be stored in the Corrosive/Base cabinet. Bottles returned to storage must be tightly capped, rinsed off and wiped down.

Spills: The best spill plan is to prevent spills from occurring. Use containment buckets and pour and mix carefully. Extra precaution is required in crowded conditions and when visibility and dexterity may be impaired by PPE.

1. Should a small base spill occur (< 100 ml), use a clean room wipe wetted with DI to wipe the spill.
2. Spills over 100 ml and up to 1 liter may require staff or EHS assistance.
3. Evacuate the clean room and Contact NanoFab staff or EHS (5-1823) for spills over 1 liter.

First Aid: Immediately rinsing areas of skin or the eyes that have been contacted by a base will reduce the severity of the damage.

1. Rinse area with water for 15 minutes.
2. Seek medical attention at Student Health or Tempe.
3. Complete incident report or detail incident to supervisor so they may complete incident report.

Waste: Pouring chemicals down a drain is a violation of federal law.

1. The person who uses the last remaining amount of chemical in a bottle must fill the empty bottle with 1L (1/4 gallon) of water and attach a hazardous waste tag and place in the chemical waste cabinet for EHS disposal.
2. Base waste is to be properly labeled and stored in the appropriately labeled base chemical waste cabinet for EHS disposal.
3. All vessels used for chemical processing will be rinsed three times with water and the rinse water will be captured in a waste bottle, tagged as hazardous waste, and placed in the base chemical waste cabinet for EHS disposal.

Oxidizers

Example: Hydrogen Peroxide

Major Hazard: By providing additional oxygen, will allow a fire to burn “hotter”

Characteristics:

This class of chemicals liberates oxygen or causes oxygen to be released from other materials.

PPE:

1. Eyes: Face shield AND Safety glasses or goggles
2. Hands: Chemical Resistant Gloves
3. Body: Chemical Gown

Handling/Use/Storage Procedures:

1. Read and understand the MSDS of the oxidizer being used.
2. Check labels to ensure correct oxidizer was selected. Do not use chemicals that are not properly labeled.
3. Oxidizers are to be transported using a chemical bucket.
4. Bases can react violently with oxidizers. Keep them separate.
5. Must be stored separately from all other chemicals, especially reducing agents such as zinc or alkali metals.
6. Keep away from any combustible materials (materials that can burn, such as papers or wood)

Spills: The best spill plan is to prevent spills from occurring. Use containment buckets and pour and mix carefully. Extra precaution is required in crowded conditions and when visibility and dexterity may be impaired by PPE.

1. Should a small oxidizer spill occur (< 100 ml), use a clean room wipe wetted with DI to wipe the spill.
2. Spills over 100 ml and up to 1 liter may require staff or EHS assistance.
3. Evacuate the clean room and Contact NanoFab staff or EHS (5-1823) for spills over 1 liter.

First Aid:

1. If an oxidizer comes in contact with your skin or eyes, flush with water for 15 minutes.
2. Seek medical attention at Student Health or Tempe.
3. Complete incident report or detail incident to supervisor so they may complete incident report.

Waste: Pouring chemicals down a drain is a violation of federal law.

1. The person who uses the last remaining amount of chemical in a bottle must fill the empty bottle with 1L (1/4 gallon) of water and attach a hazardous waste tag and place in the chemical waste cabinet for EHS disposal.
2. Oxidizer waste is to be properly labeled and stored in the appropriately labeled acid waste cabinet for EHS disposal.
3. All vessels used for chemical processing will be rinsed three times with water and the rinse water will be captured in a waste bottle, tagged as hazardous waste, and placed in the acid chemical waste cabinet for EHS disposal.

Solvents

Examples: Methyl Ethyl Ketone, Acetone, Some Developers, Some Resists

Major Hazards: Flammability and Toxicity

Characteristics:

1. Most solvents have flash points (temperature at which sufficient vapors can collect to ignite) of less than 140F (Class 2 liquids), many less than 100 F (Class 1 liquids).
2. Some solvents are water soluble (methyl alcohol), some are not (petroleum based).

PPE: Human skin serves as a barrier to some toxins, but not to all. Some toxic solvents are absorbed through the skin into the body where damage to other organs can occur. PPE provides a barrier to these toxic solvents.

1. Eyes: Face shield AND Safety glasses or goggles
2. Hands: Solvent Resistant Gloves

Handling/Use/Storage Procedures

1. Use in solvent hood. Inhalation (breathing in) of solvent vapors allows the toxin to enter the body.
2. Read and understand the MSDS of the solvent being used.
3. Check labels to ensure correct solvent was selected. Do not use chemicals that are not properly labeled.
4. Solvents are to be transported using a chemical bucket.
5. Solvents can react violently with acids. Keep them separate. Do not use acids in solvent hoods.
6. Solvents can react violently with one another. Do not mix solvents unless you know they are compatible.
7. Store solvents in flammable/solvent cabinets.

Spills: The best spill plan is to prevent spills from occurring. Use containment buckets and pour and mix carefully. Extra precaution is required in crowded conditions and when visibility and dexterity may be impaired by PPE.

1. Should a small solvent spill occur (< 100 ml), use a dry room wipe to wipe the spill.
2. Spills over 100 ml and up to 1 liter may require staff or EHS assistance.
3. Evacuate the clean room and Contact NanoFab staff or EHS (5-1823) for larger spills.
4. Contact NanoFab staff or EHS for any unexplained smells or odors in the clean room or adjacent spaces.

First Aid: Immediately rinsing areas of skin or the eyes that have been contacted by a solvent will reduce the amount of solvent entering the body.

1. Rinse area for 15 minutes.
2. Seek medical attention at Student Health or Tempe.
3. Complete incident report or detail incident to supervisor so they may complete incident report.

Waste: Pouring chemicals down a drain is a violation of federal law.

1. Bottles/containers: The person who uses the last remaining amount of solvent in a bottle must notify NanoFab staff and place it in the pass-thru.
2. Solvents: Waste solvents are to be collected in the bulk waste bottles stored in the bulk waste cabinet by the solvent hood. This is to the right of hood #5. These wastes are disposed of as NanoFab common bulk waste, so individual waste tags do not need to be made up.
3. Waste solvents not specifically collected in the bulk waste cabinet are to have a hazardous waste tag attached and placed in the solvent waste cabinet.

Compressed Gas

Examples: Nitrogen, Argon, Helium

Major Hazards:

Chemical: Asphyxiation, due to the gas displacing available oxygen AND the characteristic posed by the specific gas (some are toxic, some are corrosive, some are flammable, etc.)

Physical: Inadvertent, accidental release of pressure (from rupture or valve damage) can be devastating.

Temperature: Released gas will be much colder than in the compressed state. Care should be taken to avoid bodily harm from freezing temperatures.

Characteristics:

1. Cylinders of compressed gas come in a range of sizes.
2. Regulators are specific to the gases.
3. Cylinders are leased or rented; gases are refilled by the vendor as needed.

PPE: Requirements vary based upon chemical species and the state of the compressed gas. Refer to the MSDS for the specific gas species for appropriate PPE.

Handling/Use/Storage Procedures

1. Purchase smallest quantity suited for your needs.
2. Store in exhausted, ventilated cabinets.
3. Monitor airborne levels of toxic and flammable gases.
4. Due to the potential for devastating damage from sudden pressure release, all cylinders must be secured, whether stored, in use or in transport.
5. Transporting cylinders requires the use of a cart. Rolling cylinders is extremely dangerous.

Spills: Cylinders do not spill, they leak or release their pressurized gas.

1. NanoFab has in place a Toxic/Hazardous Gas Monitoring System (MST Life Safety System). If a toxic or hazardous gas is released, even at very low detection limits, the system will go into alarm mode. The ERC building fire alarm and Life Safety System will alarm both visually and audibly.
2. When these alarms are activated, all building occupants MUST exit the building.
3. If you have any concerns about the condition of a gas cylinder or its regulator, contact NanoFab staff prior to use.

First Aid: Never enter an area or room where someone has been injured due to unknown vapor or gas concentrations.

1. Pull the fire alarm and be available to answer questions concerning the victim's location when DPS arrives.

Waste: Disposal of empty cylinders in a dumpster is violation of federal law.

1. Empty cylinders are returned to the vendor for refilling or proper disposal.

E. Piranha Handling and Disposal Procedures

Piranha Handling

Note: **Rules are shown in BOLD** *Procedures & FYI's are italicized*

1. **Put on the appropriate personal protective equipment prior to handling any chemicals. For Piranha, this includes chemical gown, chemical-resistant gloves, safety glasses and face shield.**

2. **Piranha and its component chemicals are to be handled in an acid hood only.**

3. *Piranha ingredients are concentrated sulfuric acid and hydrogen peroxide 30%, in various ratios. Calculate beforehand how much of each reagent you will need, then measure the acid and peroxide separately.*

4. *Mixing procedure: Before mixing, place the beaker on a ceramic plate then pour the sulfuric acid into your glass container and then slowly add the hydrogen peroxide. Use a glass rod to stir the mixture. Sulfuric acid is heavier than hydrogen peroxide and will tend to go to the bottom of the container and stay there unless stirred carefully. Mixing the sulfuric and the peroxide will cause the mixture to exceed 100°C.*

5. *Place stirring rods and any other apparatus into a beaker of water when finished with them.*

6. *This solution is very aggressive when it is hot. Carefully place your samples in the piranha. Remove your samples carefully. Rinse them thoroughly in DI water to remove acid from the surfaces, and then dry your samples with N2 gas.*

Piranha Disposal

1. **Allow the piranha to cool to room temperature prior to placing the waste in an approved waste container. It can take 12-24 hours for the O2 to stop evolving. The waster container should be left in the back of the acid bench on a ceramic plate until the reaction is complete. Attach a properly completed EHS Hazardous Waste Tag to the container. The waste container should also not be capped until O2 is no longer being evolved.**

   *NOTE: If the piranha is not at room temperature when placed in a waste container and the cap is tightened, the piranha will cause the waste container to expand and probably rupture. The ruptured container will allow the acid to spray out of the rupture, potentially injuring anyone in the vicinity**. You could be the person injured!***

2. **When the mixture is finished reacting, cap the waste container and move it to the pass-thru. Immediately upon leaving the cleanroom, go to ERC-146A, remove the waste container, place it in the appropriate waste storage cabinet and unscrew cap 1 – 2 turns to vent then request pick-up by ASU EHS. (Refer to Section VI, "Chemical Waste Handling and Disposal.")**

3. **If you get piranha on you, rinse the affected area immediately; then remove contaminated clothing. Do not hesitate to use the nearest safety shower.**

4. **Notify the NanoFab staff of the incident so they can assist you in obtaining the proper medical treatment.**

F. Treatment of HF Exposure – *Know this before you need it!*

There are a lot of horror stories about HF. Take them seriously!

1. Concentrated HF is considered “extremely” toxic (4, on the health hazard scale of 0-4). However, any solution containing a source of free fluorine ions is also hazardous. A plain, concentrated ammonium fluoride solution is considered “very” toxic (3, on the health hazard scale), yet becomes “extremely” toxic when made more acidic, such as in the BOE mixtures we use at NanoFab. So even though 20:1 BOE (a mixture of HF and NH4F) has much less HF (about 7% of volume) than 49% HF it also has about 38% NH4F and is acidic. It therefore presents the same toxic hazards as 49% HF.

2. On contact, HF easily passes through skin and tissue. Because its action can be delayed for many hours, it can distribute throughout the body.

3. Negatively charged fluorine ions bind very easily to positively charged calcium and magnesium ions to form insoluble salts (CaF2 and MgF2 salts form some natural gemstones.) In the body, Ca and Mg ions are used to mediate a variety of physiological processes, such as muscle movement. Calcium is also a chief component in bone.

    a. Local tissue damage results from free hydrogen ions which causes corrosive chemical burns and free fluorine ions which cause deep tissue damage including erosion of bone.

    b. Systemic damage can occur when fluorine becomes distributed throughout the body. These conditions include hypocalcemia (loss of calcium) and hyperkalemia (too much potassium). Since calcium and potassium regulate the heart, irregular beating and cardiac arrest are manifestations. “Deaths have been **reported** from concentrated acid burns to as little as 2.5% BSA [body surface area exposed to skin contact].

4. Calcium Gluconate is used as an antidote. This provides extra calcium ions which can scavenge free fluorine ions before they penetrate and damage tissue. In cases of skin contact, calcium Gluconate gel must be applied immediately to the area of contact. In cases where systemic damage is a risk, Calcium Gluconate is administered by a healthcare professional in an IV.

5. Pure hydrogen fluoride is an extremely toxic gas which very easily dissolves in water. “Hydrofluoric acid” describes this solution form. HF easily passes between gas and liquid phases; HF- will emit toxic fumes. Although NanoFab lab safety precautions tend to emphasize protection against skin contact with fluoride-containing solutions, remember to avoid inhalation of the fumes by always working under fully exhausted areas of the wet benches.

6. Concentrated HF solutions are used in many household items, such as rust removers.

There is a general first aid kit available in the Cleanroom garment cabinet. The treatment procedure for hydrofluoric acid (HF) exposure is *very different* from that for mineral acid exposure.

If you think you have contacted HF in any way, follow these guidelines:

In any case, flush the affected area with water for 5 minutes. Remove any contaminated clothing. If you are assisting someone who is injured, make sure you are using personal protective equipment to avoid getting injured yourself! For HF burns, Calcium Gluconate or Calcium Glutamate gel is located in the refrigerators in the Cleanroom and in the Chemical Storage area.

If there is *immediate* and *severe* pain, burning, or tissue destruction: *CALL 911 IMMEDIATELY!* Apply Calcium Gluconate to the affected area while waiting for the Paramedics to arrive. Notify NanoFab staff. File Incident Report.

If there is *immediate, mild* burning, itching, or pain: *!* Apply Calcium Gluconate to the affected area. Go to Student Health for continuation of treatment and medical evaluation—take Calcium Gluconate or

Calcium Gluconate gel with you. If after hours, go to Tempe-St. Luke's for continuation of treatment. Continue treatment until the burning stops plus an additional 2 hours. Notify NanoFab staff. File Incident Report.

If there is Absolutely *no evident effect*: Take Calcium Gluconate or Calcium Glutamate with you when you leave just in case burning starts later on (HF can have delayed effects). Notify NanoFab staff. File Incident Report.

If there is *delayed* burning, itching, pain, or redness: Apply Calcium Gluconate to the affected area. Notify NanoFab Staff As soon as practical and possible. Get medical treatment if necessary. File Incident Report.

1. **Never** take pain medication for HF burns. Decreased pain is the best indication that treatment is effective.

2. In all CASES, notify the NanoFab staff and file an Incident Report, found at ***https://cfo.asu.edu/incident-reporting*** under "Incident Report."

3. If you are assisting a person with potential HF burns, ALWAYS wear full PPE before assisting the other student.

In addition to the Cleanroom: There is also calcium gluconate (or glutamate) gel in a plastic container on top of the spill kit cabinets in the following laboratories that we have recorded use of HF: ERC138; ERC 146 and ERC146A.

The reporting of a chemical burn or getting a chemical burn, in and of itself will not cause you to get a strike, while failure to do so probably will.

Please also refer to the HF treatment flow chart for additional information.

Hydrofluoric Acid (HF) Exposure Response

Know these immediate actions BEFORE the incident.

If you think you have been exposed to HF:

IMMEDIATELY – Flush the area with water for five minutes!

G. Liquid Nitrogen Hazards and Handling

Note: Rules are shown in BOLD *Procedures & FYI's are italicized*

Liquid Nitrogen Handling at NanoFab

Protective Equipment

When handling liquid nitrogen at NanoFab, the following protective equipment is required:

- **Cryogenic gloves**
- **Long pants without cuffs**
- **Close toed shoes**
- **Safety glasses**

In addition, when filling a dewar from the main tank, additional safety equipment may be needed consisting of:

- **Face shield**
- **Ear protection (not needed when filling an atmospheric pressure dewar)**

Dewar Fill Procedures

1. Contact NanoFab staff to arrange a dewar fill. **It is necessary to have two people present at all times during a fill.** If you do not have a partner, NanoFab staff will remain with you for the entire fill.

2. Collect all equipment needed for the fill, including protective equipment, any needed connectors, and if needed, the diffuser attachment.

3. Take the dewar to the LN2 tank, and have NanoFab staff open the gate.

4. Put on all needed safety equipment.

5. **Do not ever touch LN_2 or allow it to come into contact with your skin or clothing.**

6. For non-pressurized dewar systems:

    a. Attach the diffuser to the tank supply line
    b. Insert the diffuser into the dewar
    c. Make sure the supply line vent valve is closed
    d. Slowly begin opening the supply line fill valve. Make sure there is no liquid N2 coming out of the top of the dewar.
    e. Continue adjusting the supply valve until the dewar is full. It may be necessary to change the position of the diffuser in the dewar to complete the fill. Close the supply line fill valve completely.
    f. Remove the diffuser from the dewar and disconnect it from the supply line. Return the line to its holder.

7. For pressurized dewar systems:

    a. Attach the supply line to the fill connection of the dewar. DO NOT CROSS THREAD THE SUPPLY LINE FITTING! It is the user's responsibility to ensure that their dewar has the correct connection to the NanoFab supply line.
    b. Put on all necessary safety equipment, including face shield and ear protection.
    c. Open the vent valve on the dewar.
    d. Open the fill valve on the dewar.
    e. Ensure that the vent valve on the supply line is closed.
    f. Open the fill valve on the supply line.

g. The dewar will blow nitrogen out of the vent valve for the entire fill. At first, it will be warm since the fill line and dewar are warm. It will then get very cold.
h. The dewar may also release nitrogen from the overpressure valve during the fill. This is normal.
i. If the dewar is equipped with an accurate level measurement gauge, you can use that to determine when the dewar is full. Alternatively, the dewar is full when the nitrogen coming out of the vent line is partly liquid.
j. Once the fill is complete, turn off the supply line fill valve.
k. Turn off the dewar fill valve.
l. Turn off the dewar vent valve.
m. Open the supply line vent valve to release all of the LN2 from the fill line.
n. Disconnect the supply line and return it to its holder.

H. Engineered Nanoparticles

- Nanoparticles are < 100 nm in dimension and come in all shapes and form
- Little toxicity data is available – be prudent and assume nanoparticles may be toxic

- Useful resources –
  - ASU CHP Appx H has Guidelines for Nanotechnologies Related Research
  - http://www.asu.edu/ehs/documents/asu-chp.pdf

  - UC Berkeley Nanotechnology Guidelines
  - http://nano.berkeley.edu/research/73nanotech.pdf

- Potential routes for exposure - appropriate PPE is required (including respirator)
  - Skin absorption
  - Ingestion
  - Inhalation
  - Injection

- Greatest concern in NanoFab – what if nanoparticles become airborne in the facility

  - Nanoparticles can then become both a potential health hazard and a cross-contaminant
  - So we have not allowed folks to spin, for example, gold nanoparticles in the Cleanroom

- Other Thoughts

  - Best if nanoparticles are kept in solution/suspension or attached to a substrate
  - It is recommended to have a dedicated HEPA filtered hood or glove box when handling dry nanoparticles
  - Maintaining engineering controls in a multi-user facility is a more difficult proposition than for a dedicated laboratory
  - What MSDS information that exists out there for nanoparticles is incomplete
  - We can review nanoparticle use in NanoFab thru the PHA process

I. Tetramethylammonium hydroxide (TMAH)

- Tetramethylammonium hydroxide (TMAH) is widely used in micro- or nanofabrication as an etchant or developer. TMAH is typically one of several ingredients in commercial etching / stripping mixtures, although it may be used alone in a water- or methanol-based solution.

- TMAH is a quaternary ammonium salt with the molecular formula $(CH_3)_4NOH$. It can be used as an anisotropic etchant of silicon, generally at higher concentrations (25%). It is also used as a basic solvent in the development of acidic photoresist in the photolithography process, generally at lower concentrations (typically about 2.4%). While it has long been known to be very toxic if ingested, recent industrial experience indicates that skin exposure may result in serious injury or even death. There is no known antidote for TMAH poisoning through either ingestion, skin, or eye contact – immediate removal of the material using a safety shower /eyewash is critical.

Hospitalization and respiratory support has been shown to be somewhat effective. Skin exposure to >1% TMAH solutions over a few percent of the body must be treated as a life-threatening event.

- TMAH solution is a strong base, similar to sodium hydroxide. The Tetramethylammonium ion can damage nerves and muscles, causing difficulties in breathing and possibly death in a short period of time after exposure by contact, even with only a small amount of a small concentration. The action of tetramethylammonium is most pronounced in autonomic ganglia, and so tetramethylammonium is traditionally classed as a ganglion-stimulant drug. The ganglionic effects may contribute the deaths that have followed accidental industrial exposure, although the "chemical burns" induced by this strong base are also severe and play an essential role in the toxicity of the material.

- Exposure may result in intense burning of the eyes, nose, throat, lungs and skin. Depending on the level and duration of exposure, signs and symptoms may include blurred or double vision; pinpoint pupils; changes in heart rate and blood pressure; abdominal cramping, nausea and vomiting; diarrhea, excessive salivation sweating or bronchial secretions; urinary incontinence; muscle twitching, tremors or convulsions. Other symptoms consistent with cholinergic activity may also be observed.

- When handling Tetramethylammonium hydroxide (TMAH) solutions, the minimum set of personal protective equipment includes PPE requirements for bases in Section IV., D.

- If a spill occurs, refer to Section III. And Section IV., D for appropriate action for response actions.

- For additional information, refer to the following link:

    - https://www.asu.edu/ehs/sop/tetramethylammonium-hydroxide-tmah-solution.docx

Section V. Chemical Retrieval Procedures

***Right to Know**: Some components in photo resists and other compound chemicals may cause health problems in unborn children. If you are contemplating having children, **read the MSDS thoroughly** for the chemicals you will be using and **understand the effects** these chemicals may have on you and/or your unborn child.*
For more information, contact ASU EHS.

Chemical RetrievalProcedure:

This is to clarify the procedure for taking fresh chemicals from storage (ERC-145B), some definitions and our expectations of cleanroom users:

The chemicals are to be obtained form from the chemical storage room (ERC-145B) by the user (student, post doc, etc.). The individual uses the chemicals, returns the unused portion to the storage area with a NanoFab staff member or student worker by five o'clock PM the same day.

The user must PLAN for the waste chemicals!! The user is to attach a properly completed Hazardous Waste tag to the hazardous waste container (both chemical waste and rinse waste). The hazardous waste is to be placed in the pass-thru before leaving the cleanroom. Upon leaving the cleanroom, immediately go to the chemical waste storage area, remove the hazardous waste from the pass-thru and place them in the appropriate waste storage cabinet. All chemical handling guidelines are to be followed.

Working after normal business hours (which are 8:00 AM-5:00 PM) is possible by planning your work accordingly. If chemicals are needed to work beyond 5:00 PM, discuss your need with a Staff member

or student worker either by email or in person before 5:00 PM. You can then complete your work after hours.

The important part is communicating to NanoFab staff what you wish to do.

Please plan ahead: All liquid chemicals must be procured and placed in the appropriately labeled pass-thru in ERC146A by each student prior to entering the Cleanroom. After you are in the Cleanroom and determine you need more/other chemicals, you may contact a colleague (who must also have authorized access) to get the chemicals for you. Otherwise, de-gown and get them yourself. Unused solvent and base chemicals are to be stored on the top shelf of the solvent labeled sections of the pass-thru. Unused acid and oxidizers are to be placed in the left cart of the bottom section of the pass-thru.

Waste chemicals placed in the pass-thru must have a properly completed Hazardous Waste tag.

Minimal temporary placement of chemicals is permitted in the pass-thru provided it does not exceed the needs of daily usage. Some solvents & bases are stocked in the cleanroom by NanoFab staff. Please notify NanoFab staff if the supply is low.

Pass-through

NOTE: Top half is for solvents & bases (fresh chemicals on top shelf, waste on the bottom shelf). Bottom half is for oxidizers & acids (right cart is for fresh chemicals, the left cart is for hazardous waste).

Definitions:

- "Normal business day" means Mon-Fri 8:00 AM to 5:00 PM.
- "Same day" means *the same day*
- Start of business day means 8:00 AM.
- End of business or close of business means the end of a normal business day, typically 5:00 PM. It does *not* mean when you are done with your experiments or research.

The expectations we have are that all cleanroom users will become more safety conscious and follow the rules we have provided as guidance for you when working around or with chemicals.

Those that do not follow the rules will lose access to the cleanroom.

Formation and Maintenance of Chemical Super Users' Group

INITIAL STUDENT GROUP

- >300 hours of Cleanroom usage over a six month period
  - No strike recommendations over that six month period
  - No written warnings, etc. over that six month period

NEW MEMBERS

- May be nominated by self, other student or staff

RULES

- Only check out chemicals for your own use
- Use Log Book in ERC-145B when checking out chemicals
- Must maintain clean record: no strikes, warnings, etc.
- Will be given ISAAC access to ERC-145B
- Buddy system still applies

Section VI. Hazardous Waste Handling and Disposal

Note: **Rules are shown in Bold** *Procedures and FYI's are italicized*

1. **It is the responsibility of the individual to adhere and enforce ASU EHS policy with regards to hazardous waste handling and disposal. Accountability rests with the individual.**

2. **All hazardous waste that is generated during the course of an experiment must be collected by type (solvent, acid, HF, etc), with content and quantity recorded on tagged bottles and entered into the ASU EHS website at:** https://cems.unh.edu/asu/CEMS/Dashboard**. If this hazardous waste is generated in the Cleanroom then it must be placed in the appropriate hazardous waste cabinet in ERC-146A at the conclusion of the experiment or at the end of the day, but not to exceed a 12-hour time period.**

   This responsibility embraces the regulatory "cradle to grave" concept. Accurate documentation is very important to facilitate disposal, i.e., avoids any additional cost to NanoFab for the analysis of unknown chemicals, and protects EHS personnel from injury due to mislabeled chemicals. Users are requested to inform NanoFab staff if the cabinet contents are out of compliance. Please maintain vigilance when placing chemicals in the waste cabinets (bottles may have ruptured, etc.).

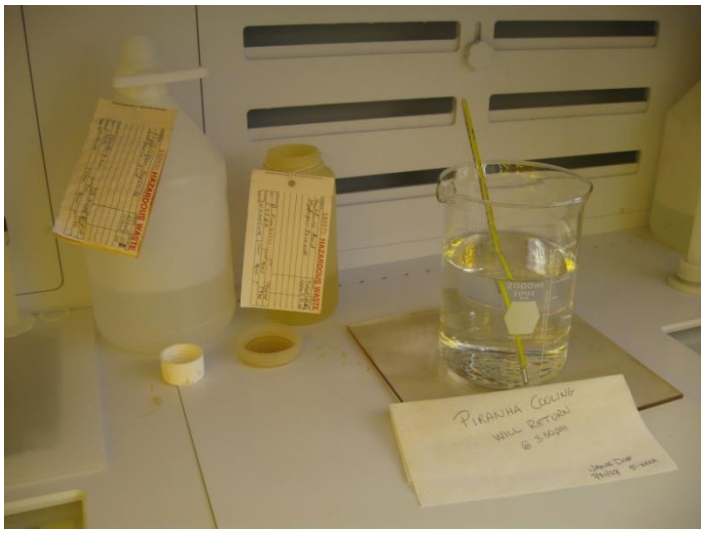
Chemical waste storage area in ERC146A

There are three exhausted cabinets designated for hazardous waste in ERC-146A. The hazardous waste category is marked on each cabinet door. Cabinets are dedicated and labeled for acid/oxidizer waste, flammable waste, and base waste. The center shelving unit holds clean (rinsed) waste bottles.

3. NanoFab and ASU EHS shall provide clean hazardous waste bottles for solvents, acids, bases and HF compounds.

    a. *Only acid and oxidizer waste can be placed in the acid waste cabinet.*
    b. *Solvent waste can be placed in the flammable waste cabinet.*
    c. *Base or alkaline waste can be placed in the base waste cabinet.*
    d. *Exotic waste or waste that contains any heavy metals should be disposed of as described in the submitted Preliminary Hazard Assessment (PHA)*

4. **Users generating hot or reactive hazardous waste may temporarily store the hazardous waste in the appropriate wet bench. The hazardous waste container must have a properly completed EHS Hazardous Waste Tag attached. Ensure it is completely reacted before placing the hazardous waste in the waste bottle (typically => 24 hours). When leaving hazardous waste chemicals to finish reacting, please fill out a note with the date, time you expect to return, NAME of CHEMICAL, your name and a contact phone number.**



Hazardous Waste – EHS hazardous waste tag attached, note as to who left it with the cap off while gases are evolving.

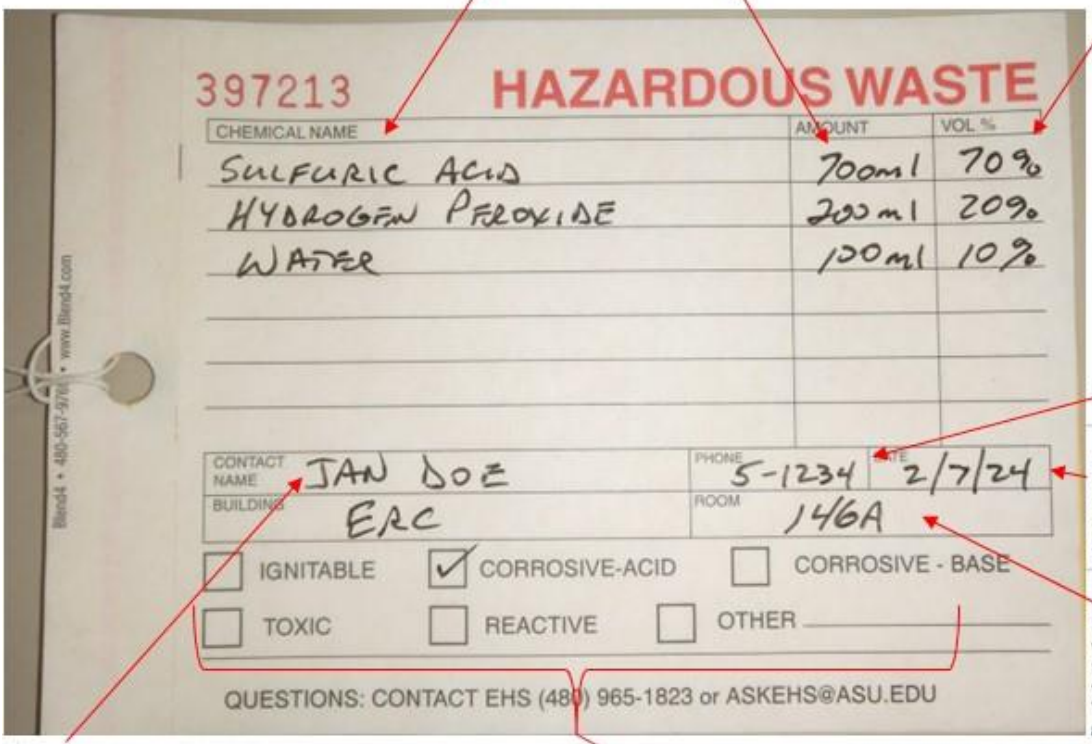
5. **Hazardous waste generators must ensure that the correct contents and concentrations of chemicals are listed on the hazardous waste tag. The contents must be written in <u>words</u> using the correct <u>IUPAC</u> name or chemical name, not trade names or formulas. Appendix B lists proper IUPAC names. *This is a regulatory requirement for accountability and transportation. <u>Please see the properly completed, sample EHS Hazardous Waste Tag illustrated on the following page.</u>***

Properly Completed Hazardous Waste Tag

Put the proper "CHEMICAL NAME" here for all components of waste. Chemical formulas or trade names do not properly communicate the appropriate information as required by law. The majority of this information can be found in SECTION I and II of the Material Safety Data Sheet, in addition, some manufacturers place this information on the side of the bottle (i.e. Olin). For off specification waste, use the guidelines of the International Union of Pure and Applied Chemistry (IUPAC) for naming chemicals.

The total amount of waste placed in the container, in liters or milliliters.

The ratio of components in the waste.



Your office/lab phone.

Date waste was first placed into the bottle. This is important because waste can only legally be kept for a limited amount of time.

Room/Lab is the location of waste generation. It is against federal regulations to relocate waste to a different lab/room. The pass-thu in the cleanroom allows for the users to legally move waste from the cleanroom to 146A. This is the only exception. Waste generated in any other lab must remain there until Risk Management collects it.

Name of the individual(s) that generated the waste. Write additional names on back of tag if more than one generator and for subsequent users, if container is to be shared among different groups. "Various" is not an acceptable indication of who produced waste.

CATEGORY: This is simply for the proper classification based on the reactivity of the chemicals to ensure the proper segregation of chemical waste during storage and transportation.

6. **Only one person is allowed per sink at one time. You must clean up and properly dispose of all waste when work is complete.**

Acid hood, waste bottles in the back. Note – one sink/one user!

7. **There is to be no storage of raw or hazardous waste chemicals at any workbench except for those immediately needed for the experiment at hand or being allowed to complete the reaction (Please see #4 in this section). No excess equipment (glassware) will be left at workbenches after the conclusion of the experiment or close-of-business.**

8. **Waste chemical bottles are to be removed from the pass-thru and placed in the appropriate waste cabinet at the end of an experiment. It is the individual (waste-generator's) responsibility to properly complete the Hazardous Waste tag on the waste bottles and place the waste in the appropriate cabinet. Appropriate safety gear must be worn when disposing of chemicals in the waste cabinets.**

9. **Empty corrosive bottles (acid, base, oxidizer) are to befilled with 1 liter (1/4 of bottle) and tagged with a hazardous waste tag as rinse waste and handled as normal hazardous waste. It is the user's responsibility to comply with these procedures.**

10. **Solvent bottles do not need to be rinsed, and must be placed in the pass-thru when empty.**

11. **Solvent waste (and some mild base and mixed solvent/base waste, e.g. developer, strippers, etc.) can be directly poured into the appropriately labeled waste bottle in the bulk waste bin next to the stainless solvent wet hood in the photobay. Use the funnel to pour the waste into the appropriately labeled bottle and remove the funnel and recap the bottle when completed….it is a violation for the user if this is not done.**

12. **For complex chemicals, contact NanoFab staff for proper empty bottle disposal procedures.**

13. **Any and all concerns about the compatibility of chemicals to be stored in waste cabinets should be addressed immediately with NanoFab staff or ASU EHS (480-965-1823). Incompatible combinations of chemicals pose an unacceptable risk to the health and welfare of people within NanoFab and the ASU community. Such a violation will be vigorously addressed.**

Section VII. Chemical Spill Procedures

Note: **Rules are shown in Bold** *Procedures and FYI's are Italicized*

1. ***Small spills (50-100 ml)*** *may be cleaned up by user using a Cleanroom wipe wet with DI water. The wipe should then be disposed of in the appropriate (acid, caustic or solvent) waste container. Wipe the spill area a second time with a wet wipe to ensure all spilled chemical has been removed. Wipe the area with a clean dry wipe until the spill area is dry.*

2. ***Large spills (100-1000 ml)*** *"**Notify NanoFab staff for assistance**", may be neutralized using Neutracid, spill kit, or materials on spill cart. Spill carts are located in the Cleanroom and in ERC146A. The neutralized liquid can be cleaned up using the same procedure as for small spills (#1 above). NanoFab staff is to be notified of cleanup materials used so they can be replenished.*

3. **Major spills (greater than 1000ml) must NOT be addressed by individuals**. *In the event of a major spill, evacuate the area and contact either NanoFab staff or University EHS. The person involved with the spill must remain nearby until either a NanoFab or EHS staff member arrives. The person involved with the spill is required to advise others from entering the affected area*. **If the situation presents an immediate threat to life and safety utilize the red emergency phone adjacent to the gowning room.**

4. **An Incident Report (see Section III) must be filed with the ASU EH&S and NanoFab for all chemical spills within 24 hours. The link to the form can be found at: *https://cfo.asu.edu/incident-reporting*.**

5. **NanoFab staff may opt to handle a major spill. If so, they must use all appropriate PPE safety gear while using the spill cart and/or Neutracid. The residual liquid must be contained and placed into suitable containers for pick-up by EHS. NanoFab staff will be trained in the use of spill kits/carts. Students may also be trained (if desired) in the use of spill kits.**

6. *If NanoFab staff determines the spill is beyond their abilities, ASU EHS is to be notified immediately (965-1823). NanoFab staff will remain close to the spill to secure the hazardous area until EHS arrives.*

7. *If an Incident Report (see Section III) has been filed, NanoFab will review the report along with the EHS and discuss the incident within 72 hours.*

Chemical Spill Response			
Size	**Small**	**Large**	**Major**
Volume	**< 100 ml**	**100 ml - 1,000 ml**	**> 1,000 ml**
Clean-up Performed By:	User	User, with NanoFab staff assistance	NanoFab staff or EHS (5-1823). Life threatening spills require calling 911 immediately.
Steps for User/Staff to Follow:	1) Wet cleanroom wipe with DI water.	1) Select clean-up material appropriate to chemical from Neutracid, spill carts or material on spill carts.	1) Evacuate area.
	2) Wipe up spill.	2) Follow instructions on spill clean-up container.	2) Contact NanoFab staff or EHS immediately. Remain nearby, but outside spill area.
	3) Repeat steps 1 and 2.	3) Wipe area where spill clean-up material was used with Cleanroom wipe wtted with DI water.	3) Provide information on spill to EHS and NanoFab staff.
	4) Wipe spill area with dry Cleanroom wipe.	4) Repeat step 3.	4) Keep others out of spill area.
		5) Wipe spill area dry with Cleanroom wipe.	
Disposal of Spill Clean-up Materials	Place wipes in container, follow procedures for Hazardous Waste appropriate to spilled material.	Place spill response material and wipes in container, follow procedures for Hazardous Waste appropriate to spilled material.	EHS will manage
Incident Report		Required, also report use of spill clean-up materials.	Required

Users unfamiliar with spill kits/carts should follow procedures for Major Spills.

For further information, please contact Environmental Health and Safety 480-965-1823, or https://cfo.asu.edu/ehs.

Thank you!

Appendix A: Glossary of Acronyms & Terms

BOE	Buffered Oxide Etch: Typically, a 20:1 mixture hydrofluoric acid and ammonium fluoride
Buddy-1	Safety rule requiring 2 people to be present in Cleanroom after normal working hours
Buddy-2	Safety rule requiring you inform someone of your presence and activity in Center laboratories with chemicals after normal working hours
COB	Close of business: Typically defined as 5PM
Cryogenic	Of or relating to low temperatures
NanoFab	Nanofabrication Facility
EHS	Environmental Health and Safety
FAQ	Frequently Asked Questions
Fab or Cleanroom	Semiconductor processing facility located in ERC146B
HF	Hydrofluoric Acid
HMDS	Hexamethyldisilazane: used to improve adhesion of photoresist
IUPAC	International Union of Pure and Applied Chemistry
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
Normal Working Hours	Defined as 8AM – 5PM Monday thru Friday
Pass-thru	The two sided cabinet that connects Cleanroom and Chemical Storage Room and allows for safe transfer of chemicals back and forth
PHA	Preliminary Hazard Analysis: a written procedure that ensures user understands the nature and hazards of chemicals used in their work
Piranha	A mixture of sulfuric acid and hydrogen peroxide used for wafer cleans
PPE	Personal Protection Equipment such as goggles, gloves, and aprons
“Right-To-Know”	A law requiring information is provided on possible chemical exposure
Safety (safe•ty)	The state of being safe; freedom from the occurrence of risk of injury, danger, or loss; the action of keeping safe.
SESHA	Semiconductor Environmental Safety and Health Association
SMBWA	Safety Management By Walking Around
Zephiran	Benzalkonium chloride solution: a treatment for hydrofluoric acid burns

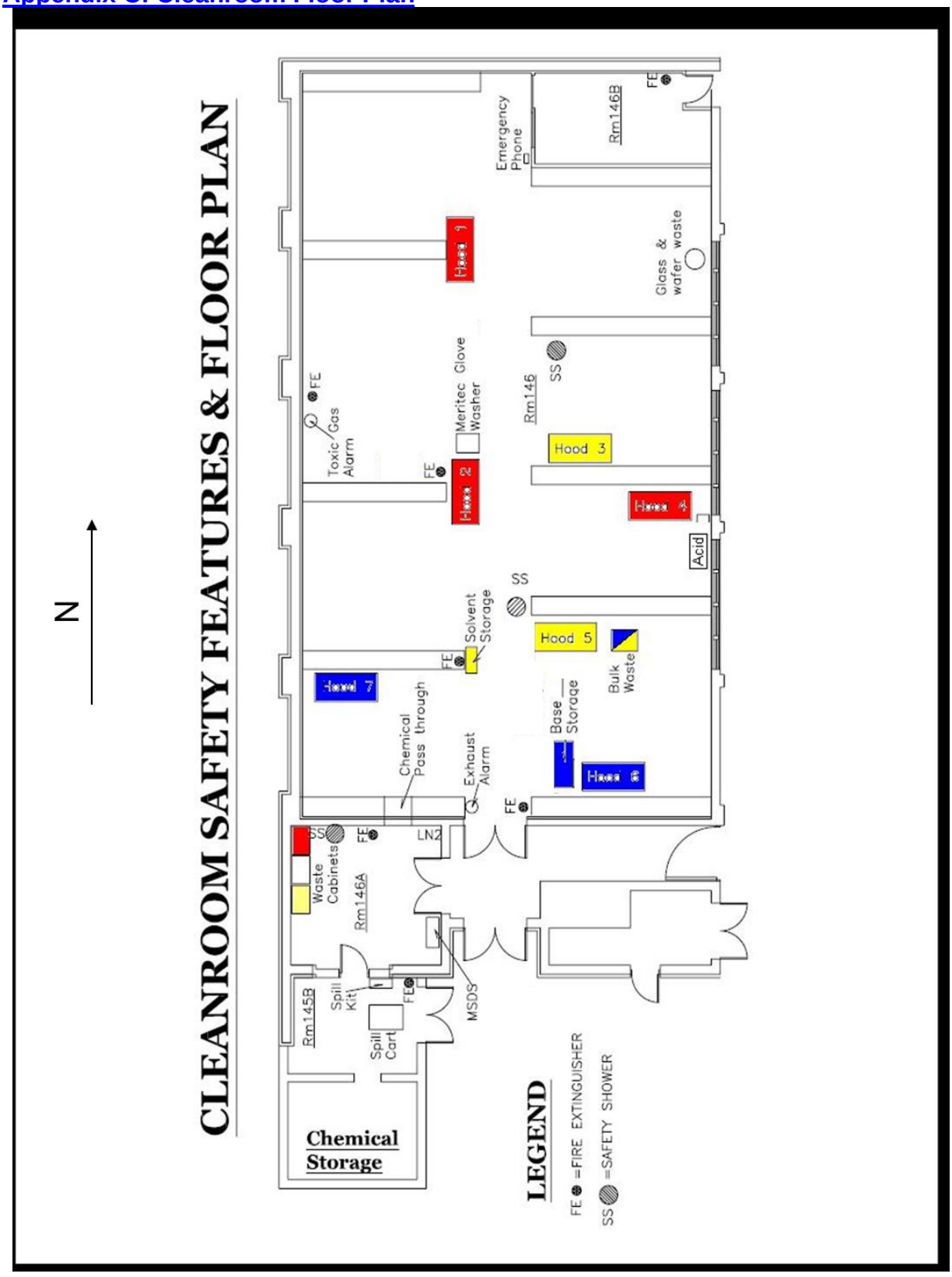
Appendix B: Common and Correct (IUPAC) Chemical Names

(For chemicals with numerous component chemicals, the underlined main hazardous chemical is to be listed)

Acids	
Common/Colloquial Name	**Correct (IUPAC) Technical Name**
Chrome Etch	Ceric Ammonium Nitrate, Nitric Acid
Copper Etch APS-100	Ammonium Persulfate
Copper Etch	Ferric Chloride
Piranha Etch	Sulfuric Acid, Hydrogen Peroxide
Gold Etch (TFA & GE)	Potassium Iodide
Nitric	Nitric Acid
Sulfuric	Sulfuric Acid
Peroxide	Hydrogen Peroxide
BOE 20:1	Hydrofluoric Acid, Ammonium Fluoride
HF	Hydrofluoric Acid
Bases	
Common/Colloquial Name	**Correct (IUPAC) Technical Name**
353 Developer	Sodium Hydroxide
APEC Resist Developer w/ Surfactant	Tetramethylammonium Hydroxide
AZ 300 MIF Developer	Tetramethylammonium Hydroxide
AZ 400K Developer	Potassium Borates
AZ 527 Developer	Tetramethylammonium Hydroxide
OCG 934 Developer	Tetramethylammonium Hydroxide
Potassium Hydroxide (K O H)	Potassium Hydroxide
Ammonium Hydroxide	Ammonium Hydroxide
AZ 400T Stripper	1-Methyl-2-Pyrrolidinone, Tetramethylammonium Hydroxide, Propanediol
EBL Chemicals	
Common/Colloquial Name	**Correct (IUPAC) Technical Name**
PMMA	Polymethyl methacrylate
MIBK	Methyl Isobutyl Ketone
CS	2-Ethoxyethanol
MEK	Methyl Ethyl Ketone
Methanol	Methyl Alcohol
Ethanol	Ethanol
Isopropanol	Isopropanol
Chlorobenzene	Chlorobenzene
Anisole	Anisole
ZDMAC	N,N-Dimethylacetamide
ZED-N50	n-Amyl Acetate
ZEP 520A-7	Anisole, Methyl Styrene/Chloromethyl Acrylate Copolymer

Solvents	
Common/Colloquial Name	**Correct (IUPAC) Technical Name**
Acetone	Acetone
IPA	Isopropyl Alcohol
Methanol	Methyl Alcohol
T1100 Rinse Solvent	Mesitylene
XP SU-8 Developer	1-Methoxy-2-propyl Acetate
QZ 3322 Polyimide Stripper	Ethanolamine, Tetrahydrofurfuryl Alcohol
Nano Remover PG (NMP)	n-Methyl Pyrrolidinone
HMDS	Hexamethyldisilazane
AP 3000 Adhesion Promoter	1-Methoxy-2-Propanol
DS 3000 Advanced Developer	Triisopropyl benzene
QZ 3501 Polyimide Developer	Dihydrofuranone, Butyl Acetate
Microstrip 2001 Photoresist Stripper	2-(2-Aminoethoxy) ethanol, n-Methyl Pyrrilidone
AZ 4620 Positive Photoresist	Propylene Glycol Monomethyl Ether Acetate, 1-Methoxy-2-Propyl Acetate, Cresol Novalac Resin, Diazonaphthoquinone Sulfonic Ester
OCG 825 Positive Photoresist	Ethyl-3-Ethoxypropionate, Novolac Resin, Methacrylic Methacrylate Copolymer, Naphthoquinone Diazide Esters, Trisubstitiuted Benzene Sulfonic Acid Derivative
AZ 5214 E Photoresist	Propylene Glycol Monomethyl Ether Acetate, 1-Methoxy-2-Propanol Acetate
AZ 1512 Positive Photoresist	1-Methoxy-2-Propanol Acetate, Diazonaphthoquinonesulfonic ester, Cresol novak resin
AZ 3312 Positive Photoresist	1-Methoxy-2-Propanol Acetate, Ethyl lactate, Diazonaphthoquinonesulfonic ester
AZ 1505 Positive Photoresist	1-Methoxy-2-Propanol Acetate
AZ 4330 Positive Photoresist	1-Methoxy-2-Propanol Acetate, Cresol-novolak resin, Diazonaphthoquinonesulfone
PMMA Electron Beam Resist	Polymethyl Methacrylate, Chlorobenzene
SU-8 Series Resist	Cyclopentanone, Epoxy resin

Appendix C: Cleanroom Floor Plan



Appendix D: Cleanroom Orientation

Cleanroom Safety Orientation consists of a 3-4 hour class followed by a proficiency test which requires a => 80% score. Once the class and test are completed, a 3 hour Wet Bench orientation occurs on the following day.

After completing this training, the student will be able to demonstrate proficiency in the following areas:

- ❑ How the ISAAC system works in the cleanroom (swipe in/out).
- ❑ How to gown and where to get gowning supplies.
- ❑ Familiarity with the back rooms where the chemicals are stored:
  - ❑ Where the empty waste bottles are kept and
  - ❑ Where the pass-thru is and how it is used
- ❑ The process for retrieving chemicals and where they are located.
- ❑ How to gown in full acid gear. Understanding of when and how the acid gear needs to be used.
- ❑ Proper acid handling and use of the acid and solvent hoods.
- ❑ How to properly carry bottles of chemicals in the cleanroom using secondary containment.
- ❑ Emergency procedures for the cleanroom. (i.e. where the phone to DPS is located, where is the HF burn treatment kit, where the safety showers and eye washes are located).
- ❑ Understanding that students are responsible for the cleanliness of the cleanroom and that all users are added to the cleanroom duties list.
- ❑ Where to find supplies and equipment around the cleanroom.
- ❑ Understanding of the Buddy System for after-hours usage and why it is important.
- ❑ Familiarity with the equipment signup and reservations using iLab.
- ❑ Knowledge of the use and submission of the “iLab Service Request” when tools are down

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ASU NanoFab
Preliminary Hazard Assessment
PHA #

Preliminary Hazard Assessment Form

Instructions: *Please fill in this form completely, **attach** Material Safety Data Sheets (MSDS) for **each** chemical you list, and send with the completed form to: ASU NanoFab Safety Compliance Officer, ERC 121 Mail Code 6206. Your faculty advisor's signature is required on the approved copy.*

Section 1. General Information		**Approved Date:**	
Date Submitted:			
Your Name		Your phone	
Faculty Advisor		Advisor's phone	
Department			
Where will work be done?		Phone in this lab	
Co-experimenter name		Co-experimenter phone	

Section 2. Process Description. *Please describe your planned process **in detail**, including experimental procedure and steps; solvents, temperature, pressure, etc. For **each** chemical used, please give trade name, full IUPAC name and quantity (per experiment), as well as any expected by-products. List any special conditions or hazards. Multiple chemicals may be listed on this form; however, each different process should be listed on its own form.*

Section 3. Chemical Need and Alternatives. *Please describe why it is necessary that this specific chemical be used. List at least three other, less toxic, chemicals and/or operational alternatives that were investigated and why they could not be implemented.*

Section 4. Chemical Listing. *Please list all chemicals (trade name and IUPAC name or components) to be used in your process (see MSDS section 2 for components and complete IUPAC names) If NFPA Hazard Codes are given on the MSDS, please list them:*

#	Chemical Name (IUPAC)	Quantity	MSDS	NFPA Hazard Code H	F	R	Special	CAS Number:
1			☐					
2			☐					
3			☐					
4			☐					
5			☐					

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PHA #

6			☐					
7			☐					
8			☐					

Add more lines if necessary.

Section 5. Stability. *Please describe any Chemical Reactivity, Incompatibilities, and Decomposition Products (see MSDS sections 5 and 10):*

Chemical Reactivity:
Incompatibilities:
Decomposition Products:

Section 6. Health Effects. *Please explain any hazards or effects of this chemical/material on the human body (see MSDS sections 3 and 11):*

Section 7. PPE. *Please check any necessary Personal Protective Equipment (see MSDS section 8):*

☐ Goggles/Safety Glasses	☐ Apron	☐ Face Shield
☐ Gloves	☐ Respirator	☐ Fume Hood
☐ Other (Please describe)		

Section 8. Waste Disposal. *Please provide details about how waste will be handled, labeled, in which cabinet it will be stored, etc. Attach a completed waste tag for this chemical specific to your planned activity.*

Signature of Experimenter: _____ Date: _____

Signature of Faculty Advisor: _____ Date: _____

Approval Signature of Lab Manager: _____ Date: _____

Approval Signature of Safety Officer: _____ Date: _____

Appendix F: Safety Photographs

Chemical storage room

Chemical pass-thru

Chemical transport carts

Buckets for transporting chemicals

Emergency Safety Equipment

Spill kit, fire extinguisher and spill cart inside cleanroom

Solvent Hood

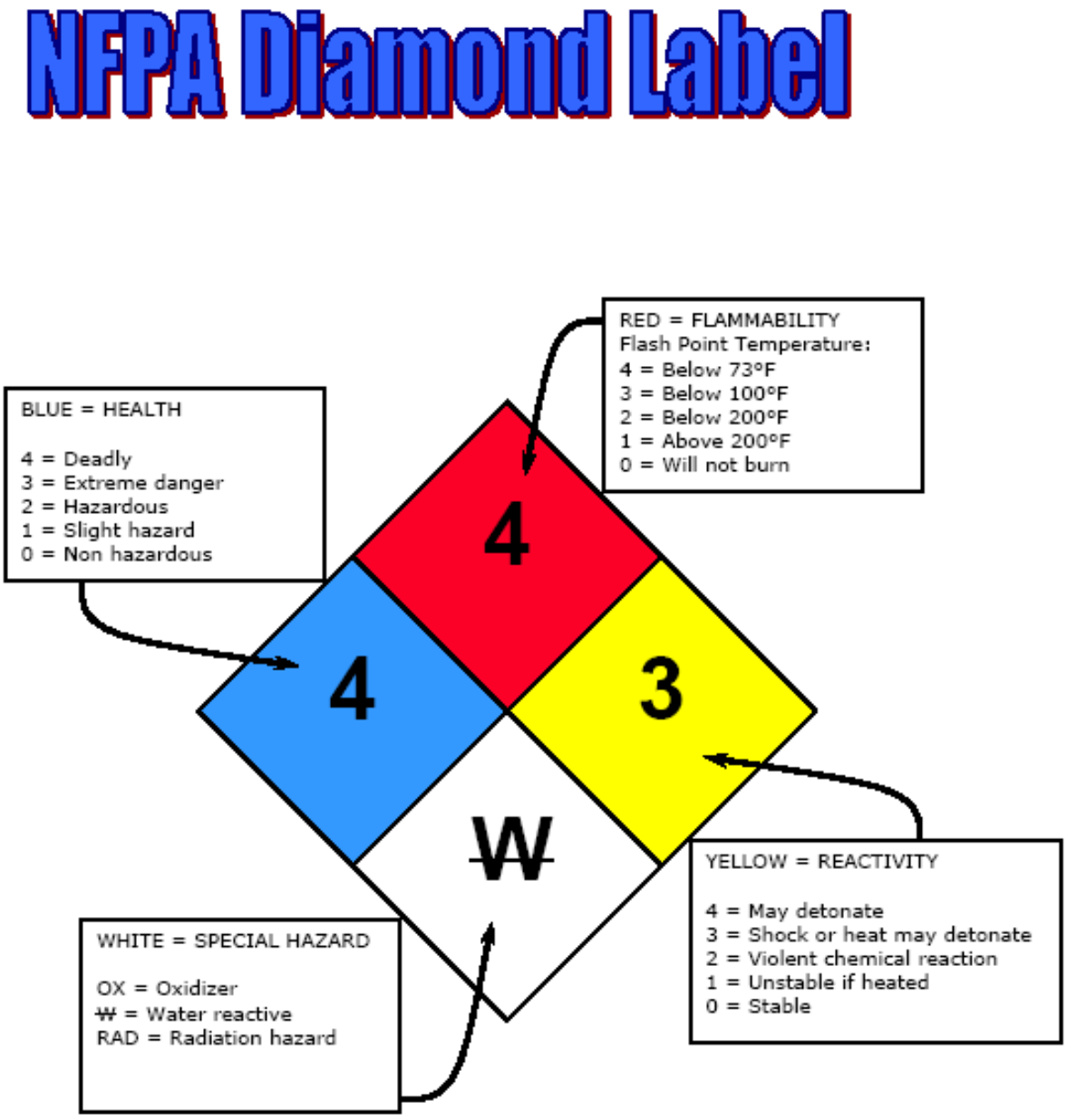
Note – Bulk waste to right of solvent hood

Use after acid processing

Chemical storage and eye wash

Glass waste

Appendix G: NFPA Hazard Diamond



NanoFab Policies and Procedures Handbook Record of Changes

Rev	Date	Changed By	Sections Modified
A	8/29/08	Team	Initial release of new format. All sections modified.
B	9/21/09	TCE	Fix various broken web links; modify Piranha mixing procedure
B.1	9/21/09	CLS	Student Duties updated
C	10/06/10	CLS	Update EHS web links; modify Section VI
D	6/3/13	P. Boland	Contact Info, LN2 handling, HF first aid procedures
E	6/21/17	CLS/SM	Updates/corrections throughout; Added Engineered Nanoparticles in Section Section IV
F	1/28/19	CLS	ADDED: Electronics Usage and NO Chemicals entering/leaving NanoFab.
G	2/16/19	KJN	Reformatted
H	6/28/19	KJN	ADDED: Section II, Subsection E, Procedure for Ordering Chemicals for Usage within the NanoFab
I	7/1/19	KJN	Updated pass-thru images
J	8/22/19	KJN	Sec. 1A, p. 4; Revised training links and policy. Sec. 1C, pp. 5-7; rewrite of Penalties to include Violation escalation policy. Sec. 4G, p. 29; Removed dead links to Air Products. Redefinition of super user; Sec. V, p. 32. Disposal of empty solvent bottles; Sec. IV-D, p. 22. Edited Spill response table; Sec. VII, p. 38. Removed Sec. VIII, FAQs.
K	9/26/19	KJN	Updated Directory p.3; Removed Jonathan Klane contact info; Section IV, Subs. E, 1.) Piranha Disposal, Changed H2 to O2 and 2.) added cap unscrew to waste storage instructions; Section 6, #2 picture and 3 updated for new single acid waste cabinet, #9 for bottle rinse and #11 added for bulk solvent waste.
L	10/22/2024	KJN	Full update and rewrite.