



Safety and User Manual

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QUATTRONE NANOFABRICATION FACILITY

SAFETY AT QNF IS FIRST

EMERGENCY CONTACTS:

Primary Emergency Contact: Dial 511 from any campus phone
University Police: (215) 573-3333
University EHRs: (215) 898-4453
After Hours University EHRs Pager: (215) 308-5266
- After the tone sounds, dial your phone number and wait for a return call. If your page is not answered within one minute, call **511**

NON-EMERGENCY SITUATIONS:

Materials Safety Data Sheets:
https://www.seas.upenn.edu/~nanofab/secure/WNF_Approved_Chemicals.html
University EHRs: (215) 898-4453
E-mail contact: ehrs@ehrs.upenn.edu
EHRs Chemical Hygiene Plan:
<http://www.ehrs.upenn.edu/programs/labsafety/chp/>

PRIMARY NANOFAB STAFF CONTACTS:

Laboratory Manager, Kyle Keenan: (215) 898-7560
Lab. Safety Specialist, Kimberly Bush: (215) 746-6549
Nanofabrication Director, Noah Clay: (215) 898-9308
Singh Building Manager, Chris Montowski : (215) 783-5725

NANOFAB WEBSITE:

<http://www.nano.upenn.edu/core-facilities/nanofabrication/>



QUATTRONE NANOFABRICATION FACILITY

SAFETY AT QNF IS FIRST

PANIC CHECKLISTS

IF A HAZARDOUS CONDITION OCCURS

1. Call the Penn Comm @ 511.
2. Evacuate the building immediately.
3. Alert others on the way out.
4. Meet the Nanofab staff at the LRSM driveway on 33rd St.

IF YOU HEAR THE FIRE ALARM

1. Evacuate the building immediately.
2. Alert others on the way out.
3. Meet at the LRSM driveway on 33rd St.

IF YOU SEE SOMEONE UNDER THE SAFETY SHOWER

1. If the victim is by themselves, you become his/her buddy.
2. Avoid contact with liquid on floor which may be contaminated.
3. Call 511 and demand an ambulance.
4. If the chemical spill is HF assist the victim in locating calcium gluconate.
5. Be ready to provide a dry garment.
6. Communicate to the responders that the individual was exposed to HF.
7. Document with e-mail to the QNF Laboratory Manager.

IF YOU GET CHEMICALLS ON YOUR SKIN

1. Approach the nearest safety shower and pull the handle to activate it.
2. Demand help but remain under the safety shower.

IF A FIRE STARTS

1. Pull a fire alarm.
2. Evacuate the building immediately.
3. Alert others on the way out.
4. Meet at the LRSM driveway on 33rd St.

1. Expectations of the QNF Community

- 1.1. Please follow procedures and use common sense. QNF staff strives to make the Facility a safe and productive environment, but your cooperation is essential. Paying attention, taking notes, following procedures, and treating the chemicals, tools and people you encounter in the Facility with respect will aid in developing good work habits that will benefit you throughout your career.
- 1.2. Remember that all work should be accomplished with safety as your absolute priority.
- 1.3. Remember to always ask for help when in doubt.
- 1.4. It is the responsibility of all users and staff to act in a professional, courteous, and safe manner at all times while in QNF.
 - 1.4.1. Users violating the operating and safety rules of the facility or endangering the safety of themselves or other users may have their access restricted, suspended, or revoked at the sole discretion of the management.
 - 1.4.2. Users are expected to be awake and alert at all times while in the facility labs.
 - 1.4.2.1. Sleeping in any of the labs will result in a suspension of lab access.
 - 1.4.2.2. Additionally, running in the lab, rough play, or other disruptive actions will not be tolerated and may result in suspension of lab access.
- 1.5. Safety is an overriding concern in all QNF laboratory activities. All operations must be undertaken with the safety of both the individual user and other users as the primary consideration.
 - 1.5.1. As a general rule, anyone violating any safety rule or otherwise compromising his or her personal safety or the safety of others will be denied access to the laboratory.
 - 1.5.2. Suspensions may be for several days, a week, or permanently. These suspensions are at the sole discretion of the facility management. Ignorance of the rules, lack of common sense, language difficulties, carelessness, and being short on time are not adequate excuses for unsafe behavior.
 - 1.5.3. In general, if a user is not certain on what the proper procedure is for something, it is better to stop and ask staff than to try and guess what to do.
- 1.6. For the most part, rules on chemical use are formulated on the basis of basic chemical knowledge, the properties of individual chemicals, and common sense.
 - 1.6.1. In many cases, rules have been created in response to specific incidents of chemical misuse by users.
 - 1.6.2. In addition, a large volume of state and federal law covers chemical use in the workplace and disposal of waste.

- 1.6.3. Some may believe our rules are restrictive and unnecessary, but they are required to maintain safety of more many researchers working in the same area.
- 1.6.4. In spite of rules and staff supervision, the primary responsibility for safety rests with the individual user.

2. Nanofab (Cleanroom) Orientation

- 2.1. All new Nanofab users must complete an orientation conducted by staff members. This orientation is an introduction to the QNF cleanroom facility and is intended to give Nanofab users a background understanding of the location, function and use of various safety, support and process equipment.
 - 2.1.1. Nanofab users must complete this orientation in order to gain access to the Nanofab facility.
 - 2.1.2. Nanofab users will learn about the facilities, processing capabilities, and the many rules that surround use of the facility.
 - 2.1.3. Nanofab users who are found in violation of the rules and procedures listed throughout this manual may lose certain Nanofab privileges or complete access to the Nanofab.
 - 2.1.4. Working in a Nanofab environment presents many hazards and it is imperative that Nanofab users fully understand the rules and regulations in place to protect them.
 - 2.1.5. It is required that Nanofab users come to staff with any questions and fully read, comply with and understand the safety manual before beginning work in the Nanofab.

3. Responsibilities

- 3.1. Most accidents in cleanrooms occur at wet benches when pouring, mixing or transporting chemicals. A great deal of this manual therefore emphasizes wet chemical safety.
- 3.2. The procedures and precautions outlined in this manual are for the purpose of protecting Nanofab workers and equipment.
 - 3.2.1. Anyone found in violation of the aforementioned procedures will suffer consequences, including a loss of privileges or even a complete loss of access to the Nanofab.
 - 3.2.2. In order to prevent such consequences, it is the responsibility of the client to review this procedures manual frequently and attentively.
 - 3.2.3. If Nanofab users see others in violation of any protocol in the manual, Nanofab users should inform them of their mistake, or confer with Nanofab staff – for example through the E-mail - in order to prevent minor or catastrophic accidents from occurring.

3.3. Laboratory Hazards

3.3.1. Hazards in the laboratory fall into two general categories.

3.3.2. Compressed Gases

3.3.2.1. QNF employs a variety of compressed gases, some of which are toxic, highly toxic, corrosive, flammable, pyrophoric or explosive. The use of these gases is thus strictly regulated. These hazards, however, can and have been minimized by the proper use of engineering controls, such our toxic gas monitoring system, use of proper equipment, proper confinement, ventilation, sensors, purges, safety valves, etc., and by procedural controls implemented by the staff.

3.3.3. Wet Chemicals

3.3.3.1. The second, more troublesome category of hazard, concerns wet chemicals, i.e. the acids, bases and solvents commonly used in lithography and etching. These are “hands on” hazards and in a multi-use facility like the QNF, are hard to control by engineering. It is precisely because they are considered “ordinary” by many users that they present a serious hazard. The chemicals commonly used in the facility can cause severe burns, tissue damage, organ damage, asphyxiation, and genetic damage if improperly used. These chemicals can enter the body by inhalation, ingestion, or absorption (either directly through the skin or through gloves) and may have either long or short-term health consequences. In addition, improper use of solvents can result in a major fire. “Ordinary” chemicals are thus definitely not hazard free. Users are expected to treat all chemicals with appropriate respect and to be aware of all possible reactions which may be created, either intentionally or by accident.

4. Nanofab Access

4.1. Nanofab users are defined as research associates, faculty members, undergraduate students, graduate students, and external Nanofab users whose home institution has signed the User Agreement. ALL prospective Nanofab users are required to complete the each step detailed on QNF’s website at:

http://www.seas.upenn.edu/~nanofab/pages/WNF_Access.html

5. General Rules & Restrictions

5.1. The following rules are to be observed by all persons qualified to work in the Nanofab.

5.1.1. Only individuals certified through registration and orientation are allowed to enter the Nanofab.

5.1.2. All Nanofab equipment usage, when applicable, must be entered in the respective log manual along with any unusual occurrences.

- 5.1.3. Nonessential items (tools, books, etc) will not be allowed to accumulate and will be removed from the lab at the discretion of the Laboratory Manager and the Nanofab Staff.
- 5.1.4. The Nanofab user should check Nanofab gown and PPE for contamination. Every QNF user should eliminate contact between gloved hands and the face as gloves may be contaminated.
- 5.1.5. In order to use equipment, the client must have a complete understanding of equipment and operation and be a certified user.
- 5.1.6. The Nanofab user must have a complete understanding of all the chemicals at the wet bench or equipment that they are using. Reviewing the MSDS sheets so that the hazards, risks, and methods for responding to incidents is a good way to begin.
- 5.1.7. Most importantly, no user shall ever work alone while performing hazardous work.
 - 5.1.7.1. Hazardous work comprises processing with strong acids and strong bases. Use of these chemicals is limited from 8:00AM to 7:00PM Monday to Friday on days when staff is present.
 - 5.1.7.2. Staff personnel are not present on University holidays, weather emergencies, cancellations, etc.
 - 5.1.7.3. If performing hazardous work, every Nanofab user should have a buddy who is qualified and present at all times on the laboratory to help in the event of an incident.
- 5.1.8. Food and drinks are not allowed in the Nanofab.
- 5.1.9. No smoking is allowed 30 minutes before entering the Nanofab.
- 5.1.10. Only use pens. Pencils are not allowed in the Nanofab.
- 5.1.11. Other items not allowed in the Nanofab are books, book bags, and other unnecessary items.
- 5.1.12. Nanofab users should try to avoid sneezing and coughing in the Nanofab. Breathing directly on a surface or wafer should also be avoided.
- 5.1.13. Singing, whistling, and chewing gum produces severe contamination and should be avoided.
- 5.1.14. Nanofab users should not enter the service corridors (except in case of emergency).
- 5.1.15. Nanofab users should always make sure that their area is clean before they leave. Nanofab users should thoroughly clean and dry the area they have used, along with any tools or equipment.
- 5.1.16. Use of earbuds, headphones and playing of any music is prohibited.

6. Hours of Operation

- 6.1. The Nanofab is open 24/7 every day of the year unless maintenance or unforeseen circumstances require closure.

- 6.1.1. Scheduled down times for the Nanofab will be posted on the home page of the QNF web site.
 - 6.1.2. Unforeseen closing will be posted on the QNF web site and notifications will be sent out by email to the “Nanofab Client” list serve.
 - 6.1.3. While the Nanofab is open 24/7, there are certain restrictions and policies that must be abided for maintaining privileges of Nanofab access by each client of the facility.
- 6.2. Staff Maintained Business Hours are Monday through Friday 8:00AM-7:00PM with the exception of University holidays, weather emergencies, University cancellations, etc.
- 6.3. Only personnel who have completed the training listed above are permitted to enter the Nanofab.
- 6.3.1. No Nanofab client can work in the Nanofab alone if their intent is to work in the Wet Process Bay.
 - 6.3.2. Nanofab users must always have a buddy present within QNF for hazardous work.

7. Nanofab Attire

- 7.1. Only full-length long pants, a minimum of short sleeve shirts and closed-toe, flat bottom shoes are allowed in the Nanofab.
- 7.1.1. Prohibited lower body garments: skirts, short pants, shorts or anything excessively baggy.
 - 7.1.2. Prohibited upper body garments: tank tops, halter tops and spaghetti straps (no exposed belly/back skin).
 - 7.1.3. Prohibited footwear: heels, work boots, heavy boots, shoes that leave any area of the foot exposed below the ankle.
- 7.2. Safety Glasses
- 7.2.1. Safety glasses must be worn at all times in the labs.
 - 7.2.2. A user may provide their own, providing they meet the ANSI Z87.1-2003 standard.
 - 7.2.3. Safety glasses may only be removed when using optical microscopes. Users should be sure to remember to put them back on when they step away from the microscope.
 - 7.2.4. Safety glasses are not a substitute for face shields when working with chemicals.
- 7.3. Contact Lenses
- 7.3.1. Contact lenses are allowed in all areas of the facility. In the past, it was not considered good laboratory practice to wear contacts in any laboratory, but the American Chemical Society changed its’ recommendation, and the QNF has adopted its practice.

- 7.4. Bunny suits, safety glasses, booties, hair nets, mustache/beard nets and gloves must be worn at all times in the Nanofab.
- 7.5. To enter the gowning room, Nanofab users will swipe their Penn ID. Nanofab users can then enter the gowning room and store any unneeded personal items on the shelves to the right of the entry door.
 - 7.5.1. Only one user is permitted to enter the pre-gowning area per swipe. Tailgating is strictly prohibited.
 - 7.5.2. Each user should clean the soles of shoes by using the sticky mat (located on the floor just inside the pre-gowning entrance) by taking 5-10 steps on the sticky mat.
- 7.6. In the Nanofab pre-gowning area, Nanofab users should don a set of blue shoe covers (booties).
- 7.7. Pre-gowning Procedure
 - 7.7.1. Place shoe covers over shoes.
 - 7.7.2. Wipe-down the surface of any items to be brought in QNF with IPA and water mixture and wipes.
 - 7.7.3. Don a hair net. Nanofab users should make sure that all of their hair is covered.
 - 7.7.3.1. No hair should protrude from the hair net.
 - 7.7.4. Don a face mask or beard cover such that both mouth and nose are covered.
 - 7.7.5. Place gloves on both hands.
- 7.8. Final Gown Procedure
 - 7.8.1. Don a hood garment.
 - 7.8.2. Don a suit garment. Ensure hood is completely tucked inside suit.
 - 7.8.3. Don boot garments.
 - 7.8.4. Safety Glasses are required. Users may bring their own or borrow from the storage rack next to the sliding door. In place of safety glasses, regular glasses with side shields are also acceptable general eye protection (not replacement for face mask when required).
- 7.9. Use the mirror to ensure all apparel is properly worn.
- 7.10. Collect all items brought into the gowning area and take into the Nanofab.
 - 7.10.1. Allowed items include: pens, cell phones, approved notepads with cleanroom paper, tablets, laptop computers, and memory sticks.
- 7.11. Nanofab users should then step on the sticky mat located just before they enter through the sliding door and make 5-10 baby steps.

- 7.12. Prior to leaving, nanofab users should verify login/logout state on all equipment used to ensure they have been properly shut down. For example verify that vacuum systems without automatic cross-over aren't left with roughing pump valve open.
- 7.13. Nanofab users should also make sure that all their work areas are clean and safe. In addition, Nanofab users should ensure they have retrieved all items brought into the space. Exceptions include items in storage on the user storage shelving.
- 7.14. Items found in the facility by staff will be collected and placed in bins in the service corridors. Please contact staff if you suspect something has been left behind and collected.
- 7.15. Upon leaving, nanofab users should step into the gowning room quickly and completely allow the sliding door to close behind them.
- 7.16. Ungowning Procedure Part I (in final gown area)
- 7.16.1. Remove Nanofab boot garments.
 - 7.16.2. Remove Nanofab suit garment.
 - 7.16.3. Remove Nanofab hood garment.
- 7.17. Ungowning Procedure Part II (in pre-gown area)
- 7.17.1. Remove face mask or beard cover.
 - 7.17.2. Remove hair net.
 - 7.17.3. Remove gloves.
 - 7.17.4. Collect belongings.
 - 7.17.5. Remove shoe covers and place in bootie recycling bin if OK. Dispose of booties in trash if torn, dirty or otherwise unfit to be used.
 - 7.17.6. Swipe card at exit door.
- 7.18. The following are items that can be reused:
- 7.18.1. Cleanroom Suit: (bunny suits): hang on the rack with the hanger assigned with your name
 - 7.18.2. Hood: stored inside the sleeves or snap to collar of your coverall
 - 7.18.3. Cleanroom Boots: hang with your coverall on hooks
 - 7.18.4. Safety glasses: stored in your tool box or replace QNF safety glasses in the bin to the left of the sliding door in the Gowning Area.
- 7.19. Items that should be discarded once used:
- 7.19.1. Face masks
 - 7.19.2. Hair (bouffant) caps
 - 7.19.3. Gloves
- 7.20. The following is the cleanroom garment laundering schedule:

- 7.20.1. Nanofab garments are laundered every week by an external vendor. If a gown becomes chemically stained, it is best for it to be washed as soon as possible. The laundry container is in the gowning room.
- 7.20.2. If there is an emergency evacuation that involves wearing garments outside of the Nanofab, the garments must be placed in the laundry bin and a fresh set of garments must be selected.

8. Nanofab Materials and Cleanliness

- 8.1. Keeping cleanrooms clean and organized is every user's responsibility
- 8.2. Enforcement procedures may be necessary to ensure safe and effective operations.
- 8.3. Absolutely no food or drink should be brought into QNF or consumed while using any QNF tool.
- 8.4. Do not bring non-cleanroom items into a cleanroom.
- 8.5. Do not take cleanroom items out of a cleanroom.
 - 8.5.1. Do not borrow chemicals.
- 8.6. Always clean up the working space you have used before moving to the next station
- 8.7. Don't leave/store anything on public areas, such as machine tops, bench surfaces, on/under tables, etc., without permission from a cleanroom supervisor
- 8.8. Keep non-shared items, such as tool boxes, wafers, glassware, etc., in the storage area assigned to you when not in use
- 8.9. No food is allowed in the cleanroom.
- 8.10. Users are not authorized to enter the cleanroom service chaise areas.
- 8.11. Writing Paper, Notebooks and Pens
 - 8.11.1. Use only cleanroom paper and notebooks inside a cleanroom.
 - 8.11.2. Use non-retractable ball point or nylon tipped pens. Don't use pencils or crayons.
- 8.12. Bringing Materials into Cleanroom
 - 8.12.1. Prepare at least one tool box for storing your non-shared items
 - 8.12.2. Wafer processing tools, such as tweezers, scribes, timers, glassware, etc., should always stay inside your own tool box when not in use
 - 8.12.3. Always keep dedicated cleanroom tools inside the cleanrooms

8.12.4. Don't bring non-cleaned tools into a cleanroom without cleaning and permission.

8.13. Glassware and Plastic Containers

8.13.1. The laboratory provides general purpose glassware.

8.13.2. To mitigate cross-contamination, users are responsible for providing their own glassware and plasticware for chemical handling.

8.13.3. Users are advised to obtain watch glasses, graduated cylinders, and small storage containers.

8.14. Tweezers

8.14.1. Users are advised to obtain both metal and Teflon tweezers.

8.15. Storage

8.15.1. Store your tool box and other non-shared materials in the racks in the clean aisle.

8.15.2. Do not take/use other users' non-shared items without their permission.

9. Wet Bench Utilization

9.1. QNF classifies wet benches in two groups – those that require a face shield and those that require full personal protective equipment.

9.1.1. All benches in the Wet Process Bay require full PPE (personal protective equipment) which consists of a face shield, apron and heavy nitrile gloves.

9.1.2. All other QNF hoods (e.g., lithography and PDMS), which require a face shield.

9.2. All chemicals brought into QNF require approval by the Laboratory Manager and must have a valid MSDS (materials safety data sheet).

9.2.1. Chemicals cannot be brought into QNF from the pre-gown entrance. Hazards are too great for injuring many people if a spill occurs.

9.2.1.1. If you must bring a chemical in QNF, please contact a staff member and meet them at the West Loading Dock, adjacent to LRSM.

9.2.1.2. The staff person will bring the chemical(s) to a designated spot in the cleanroom for you.

9.2.2. If shipping approved chemicals to the QNF from elsewhere, it is important that they are shipped following all Department of Transportation (DOT) laws for hazardous shipments.

9.2.2.1. This generally requires that the person packaging the material has received official DOT training for shipment of hazardous materials.

9.2.2.2. Users should check with EHRS for more information regarding shipping chemicals.

9.3. Chemical transport within a bay in the cleanroom is permitted without the use of chemical bucket. If transporting a chemical from one bay to another bay in the cleanroom, a chemical bucket must be used.

- 9.4. All chemicals lids require proper labeling (even water). The U.S. Environmental Protection Agency (EPA) defines any uncovered container not in current use as an illegal disposal of the chemical by evaporation. Even if the user never plans on walking away from the container, lab policy requires that they have a lid for it. This policy is required for all containers including containers of water.
- 9.5. Always pour chemicals inside a wet bench and away from your body.
- 9.6. QNF stocks and supplies the chemicals commonly required for processing in the facility. Users are neither allowed to bring in their own stocks of these chemicals or to appropriate as a private stash any of these chemicals.
- 9.6.1. We simply do not have room for researchers to have private bottles of chemicals.
- 9.6.2. The one major exception to this is with resists and other expensive lithography chemicals, where research groups that purchase their own may store it in the facility for their exclusive use.
- 9.6.3. Working stocks of chemicals are kept in the chemical cabinets located under the hoods or nearby. Extra stock is kept in service corridors, accessible by staff only, therefore users may not replenish the cleanroom cabinets.
- 9.7. Chemicals supplies carried from room to room in the lab must be carried in a rubber chemical carrying bucket or carts.
- 9.7.1. Users carrying bottles within a single bay are not required to use the rubber chemical bucket.
- 9.7.2. All chemical containers moved outside of a hood must be sealed with a screw top lid. Open containers or containers with unattached lids may not be carried around the lab, even if they only contain water.
- 9.8. Users must not open a new bottle until the old one is empty.
- 9.8.1. When a chemical bottle is emptied, it must be thoroughly rinsed before disposal in the chemical bottle trash.
- 9.8.2. An automatic bottle washer located in the General Chemistry aisle is available for this function.
- 9.8.3. Instructions on the use of this system are covered in the orientation. If the system is offline for any reason, users are still responsible for rinsing bottles manually at the sink.
- 9.9. Chemical bottles that contained chlorinated solvents like methylene chloride, must also be rinsed with isopropanol to get rid of the residual material before being rinsed with water.
- 9.9.1. Chemical bottles that contained a polymer solution (photoresists, spin-on glasses, etc.) need to have the polymer material completely rinsed out of the

- container before it can be disposed. Users must determine the correct solvent to do this and into what waste bottle the solvent rinse should go into.
- 9.9.2. In many cases, Acetone is not the correct solvent for this.
- 9.9.3. Contact the staff responsible for that area of the lab for assistance in the proper solvent choice.
- 9.10. Everything in a wet bench must be labeled, even rinse water.
- 9.11. Attach a cleanroom sticky note to on the lid on each container.
- 9.11.1. Do not use cleanroom wipers for labels.
- 9.11.2. A proper label consists of the chemical name, user name and date. An example:
9.11.2.1. Acetone, Joseph Millitorr, 12/21/2014
- 9.12. Every container requires a lid, even rinse water. The labware should be made of the appropriate material and just large enough to easily work with the samples to be processed. Do not use containers that are too large for the samples, as this will use more chemicals than needed and create more waste to dispose. Disposal costs for chemicals are often much more than the original chemical costs so users should try to minimize wasteful use of the chemicals.
- 9.13. Wet benches exhaust fumes from the cleanroom. Do not place any part of self inside bench except for gloved hands and forearms.
- 9.14. Benches are equipped with nitrogen, aspirators and deionized water.
- 9.15. Hot Plates
- 9.15.1. Allow hot plates to warm before use. With the exception of lithography hot plates, turn off after use. Do not heat containers of solvents on hotplates. Use heated baths.
- 9.15.2. Hot plates may seem to be a very basic piece of lab equipment but they can be very dangerous if used in an improper manner with the chemicals in the facility. Hotplates are tightly controlled at the facility due to the risk of being left unattended and creating a hazardous situation or fire.
- 9.15.3. The hotplates in the lithography areas should only be used for the baking of resist on substrates.
- 9.15.4. When using a hotplate, users are required to be present in the facility, or have someone designated to watch over the hotplate if they need to step out for a moment. The user should be actively checking on the material on the hotplate, using a thermocouple to monitor the solution temperature to make certain that the chemical is not heated to a dangerous temperature. This is especially important as the material is being heated up to the operating temperature, as small solution volumes can quickly heat up to a dangerous temperature.
- 9.15.5. Only glass containers should be used on hotplates, no matter what temperature the material is being heated to. Due to this requirement, hydrofluoric acid

solutions are never to be heated on hotplates in the facility.

- 9.16. Spinners
 - 9.16.1. Require a separate training
 - 9.16.2. Users need to leave spinners as clean as they found them. Before use you may want to line bowl with foil. Do not apply more resist than required.
 - 9.16.3. Never squirt solvent down a spinner shaft.
- 9.17. All acids and bases are disposed of by aspirating chemicals from beakers.
 - 9.17.1. Rinse the aspirator surface exposed to chemicals when done
- 9.18. All solvents are disposed by pouring waste into cup sinks.
- 9.19. All rinse water can be poured into the deep gooseneck sinks.
 - 9.19.1. Never dispose of rinse water in a cup sink, even if it is solvent contaminated.

10. Phone Utilization

- 10.1. There are phones located in each bay near the main clean aisle. Dial 9 to reach off-campus.
 - 10.1.1. Phones are intended for hazard communication and within campus communications; not for personal use or laboratory business.
- 10.2. Please refer to the emergency contact information at the beginning of this manual for emergency and non-emergency contact phone numbers.
- 10.3. Cell phones, PDAs and tablets may be brought into the cleanroom.
 - 10.3.1. Ensure these items are removed from clothing and wiped down prior to donning cleanroom garments.

11. Safety Considerations

A Note on Emergency Response

In case of a fire or medical emergency immediately call 511 from any University phone or 215-573-3333 from your cell phone. Report the emergency and follow the dispatcher's instructions. In the event of a chemical spill notify Facility staff. If a staff member cannot be reached please call EHRS (215-898-4453) Monday through Friday from 8:00 am to 5:00 pm; outside EHRS' regular hours call their emergency pager at 215-308-5266 - after the beeps dial your phone number and wait for a return call. If your page is not answered, call 511.

Medical evaluation is required for all chemical exposures. Students should report to Student Health Services (3535 Market Street Suite 100, Phone: 215-746-3535). Faculty and staff should report to Occupational Medicine located on the 1st floor of the Silverstein Pavilion (34th and

Spruce St) in the Hospital of the University of Pennsylvania. All others should report to the Emergency Room located on the ground floor of the Silverstein Pavilion at the Hospital of the University of Pennsylvania. Please see the special procedure related to [Hydrofluoric Acid](#) exposure. Please take some time to identify the shortest route to take in case you need medical evaluation. If you are in doubt as to what to do, please call University Police at 511 for assistance.

After 5:00 pm and during weekend and holidays all users should report to the Emergency Room located on the ground floor of the Silverstein Pavilion at the Hospital of the University of Pennsylvania.

If there is a Facility problem, such as a water leak, strange noise, smell, etc., please notify QNF staff. If a staff member cannot be reached please contact the Building Manager (M-F, 7:30 am to 6:00 pm) or 215-746-6620 (after hours). Depending on the nature of the situation it may also be appropriate to call EHRs.

11.1. First Aid for Minor Incidents

11.1.1. Remember 511. People often become so involved in the unfolding emergency situation they forget that help is a phone call away. Initial response to an emergency event is dictated by the emergency. Evaluate any situation before attempting to give aid. Nanofab users should not expose themselves to hazardous atmospheres, chemical contact or other dangers while attempting to give aid. Responses to some common potential laboratory incidents are described below.

11.1.2. Chemical Inhalation: The victim should seek medical attention.

11.1.3. Chemical Ingestion: Nanofab users should immediately go to the emergency room or call 511 for advice on treatment for poisoning and chemical toxicity. The client should not induce vomiting unless directed to do so by a health care provider.

11.1.4. Thermal Burn: Nanofab users should immerse the burned area in cold water or hold under cold running water until the pain stops and then cover with a sterile dressing. If the burn is severe, Nanofab users should seek medical attention.

11.1.5. Bleeding: Nanofab users should hold a clean pad directly on the wound and apply hand pressure. If necessary, elevate the bleeding extremity and apply pressure to a pressure point to reduce blood flow. If the bleeding is excessive, does not stop or is from a deep wound Nanofab users should seek medical attention.

11.1.6. Clothing Fire: Nanofab users should put out burning clothing or hair by dousing the victim in a safety shower or other water source. If a safety unavailable, have the victim roll on the floor to put out the flames.

11.1.7. Always call for medical attention for the victim before administering first aid and report the incident to the laboratory manager. If EHRs requests an incident report for the accident, you will be notified.

11.2. MSDS Library

- 11.2.1.1. The MSDS library for the Center can be accessed online at:
 - 11.2.1.2. https://www.seas.upenn.edu/~nanofab/secure/WNF_Approved_Chemicals.html
 - 11.2.1.3. An MSDS should be referred to before using an unfamiliar or new chemical. If the MSDS for the chemical a client wishes to use are missing from the website let the staff know.
- 11.3. Material Request
- 11.3.1. If Nanofab users require a new type of chemical, contact the Laboratory Manager.
- 11.4. Personal Protective Equipment
- 11.4.1. A face shield is required when working at all benches that are NOT located in the Wet Process Bay.
 - 11.4.2. Full PPE (Personal protective equipment) is required when working at the wet benches in the Wet Process Bay. PPE consists of a face shield, apron and heavy gauge nitrile gloves that extend to mid-forearm.
 - 11.4.3. PPE is intended for protection against chemical spills and are considered chemical resistant, NOT chemical proof.
 - 11.4.4. No personnel wearing PPE must be found outside the Wet Process Bay unless he/she is tending to an emergency situation.
- 11.5. PPE must be removed using the following protocol:
- 11.5.1. Wash Gloves.
 - 11.5.2. Dry gloves using wipes.
 - 11.5.3. Dispose of gloves.
 - 11.5.4. Remove Face Shield.
 - 11.5.5. Hang face shield.
 - 11.5.6. Hang apron if it is dry. Otherwise, dispose of apron.
 - 11.5.7. Chemical Gloves are for personal protection against chemical spills.
 - 11.5.8. Never immerse gloves in chemicals as they are only chemical resistant, NOT chemical proof.
 - 11.5.9. Always wear when working with acids and bases in the Wet Process Bay.
- 11.6. Video Monitoring
- 11.6.1. The Nanofab is equipped with high definition video cameras that allow for remote monitoring of the rooms in the event of an emergency. They also have a recording capability.
- 11.7. Fire Alarms
- 11.7.1. Fire alarm pull stations are located in the gowning area and adjacent to the two main emergency exit doors along the main Nanofab corridor. They are intended to alert building occupants of a fire or similar emergency requiring immediate

evacuation. If a fire alarm sounds and/or a fire alarm strobe is observed, immediately exit the Nanofab and gather at rally point in front of Pierce Hall.

11.8. Fire alarm pull stations located on the front face of wet benches will activate carbon dioxide discharge into the respective bench. Each bench of stainless steel construction contains ultraviolet and infrared sensors for flame detection and will trigger carbon dioxide discharge. These alarms are intended to suppress a fire inside the respective bench and will alert building occupants in an identical way to other cleanroom fire alarm pull stations.

11.9. Toxic Gas Monitoring System

11.9.1. The toxic gas monitoring system is intended to monitor concentrations of certain gases, gas handling equipment status and UV/IR fire detectors in the Nanofab and support areas to ensure the safety of personnel. If there is a toxic gas detection event of a given chemical, all upstream gas sources are shut-down at their respective source.

11.9.2. BLUE LIGHT strobes prompt for IMMEDIATE EVACUATION (exit through nearest emergency egress and gather at the rally point). Blue strobe lights are located in every area of the cleanroom.

11.10. Safety Showers

11.10.1. Safety showers are for chemical decontamination or fire suppression on a person or their clothing. Each shower also contains an eye-wash station. Showers are located in each bay containing a wet. To operate the shower, locate self beneath the shower, pull the lever hanging from the shower and water will begin to flow. To operate the eye-wash, place eyes in the center of the eye-wash bowl, push the lever on the side of the bowl and water will begin to flow. If exposed to chemicals, rinse the affected area for a minimum of five minutes, seek help immediately and dial 511 from the nearest phone.

11.11. First Aid Kit

11.11.1. The First Aid kits are located in each bay of the cleanroom. It is for addressing minor injuries and minor burn pain relief. It also contains calcium gluconate "Calgonate" for HF exposure. Calgonate is also located in the Wet Process Bay.

11.12. Chemical Classes and Hazards

11.13. Toxic compounds are a class of substances that, upon exposure, may result in death or serious debilitation. Exposure to chemicals in the laboratory can occur by several different routes:

11.13.1. Inhalation

11.13.2. Contact with skin or eyes

11.13.3. Ingestion

11.13.4. Injection

- 11.14. Toxicity information is available on the material safety data sheet of each chemical. Chemicals in the Nanofab are EXTREMELY HAZARDOUS. The Nanofab contains some of the most dangerous chemical categories including strong acids and bases, corrosives, and flammables. Appendix 1 lists some common hazardous chemicals used in the lab and their concentrations. These concentrations, necessary for nanofabrication and microfabrication, are much higher than those found in conventional undergraduate labs and can cause severe damage to human tissue. Therefore, Nanofab users must be alert and cautious when using these chemicals to avoid all contact with them.
- 11.15. Acids have a pH of less than 7. Chemicals can be identified as acids if they have a name ending in 'acid' or if their chemical formula is of the form $HX(aq)$ or $HaXbOc$.
- 11.16. Bases have a pH of greater than 7. Chemicals can be identified as bases if they contain hydroxide (OH^-), carbonate (CO_3^{2-}), or hydrogen carbonate (HCO_3^-) anions. Ammonia (NH_3) is also a base. Caustic is another word for a base, which may also be referred to as alkalines.
- 11.17. Corrosives have the tendency to cause deterioration of metal surfaces. Strong acids and bases are corrosives. Corrosives are chemicals which erode the skin and the respiratory epithelium and can be very damaging to the eyes. When inhaled, the vapors of corrosives can cause severe bronchial irritation. Appendix B contains a list of some of the corrosive liquids used in the Nanofab.
- 11.18. Flammables are compounds whose vapors are easily ignitable at room temperature. Flammables can be identified by looking at the MSDS sheet for the chemical.
- 11.19. Halogenated solvents contain an element from the halogenated (second to last) column on the periodic table. These elements are: Fluorine, Chlorine, Bromine, Iodine, and Astatine.
- 11.20. Inorganic acids have chemical formulas that do not contain carbon.
- 11.21. Non-halogenated Solvents are any solvent that does not contain an element from the halogen class (second from last column of the periodic table).
- 11.22. Organic acids have chemical formulas which contains carbon.

- 11.23. Oxidizing agents are materials which gain electrons when they react with other substances. This reaction may result in explosion or fire.
- 11.24. Peroxide formation in laboratory solutions and reagents by auto-oxidation has caused many laboratory accidents, including unexpected explosions of residues remaining after solvent distillation. Many liquid, a few solid and a few gaseous organic and a few inorganic solid compounds form peroxides over time. Peroxides form by the reaction of the chemical with oxygen allowed in the headspace of chemical containers once the container is opened for the first time. Most organic peroxides are sensitive, to varying degrees, to shock, heat or friction. The rate of peroxide formation will depend upon the compound. Some peroxides quickly build up to an explosive level and some are only explosive on concentration, such as when a solvent is distilled.
- 11.25. Reducing agents become an electron donor when they react.
- 11.26. Solvents are the component of solution that is present in the greatest amount and is capable of dissolving another substance.
- 11.27. Incompatible Chemicals
- 11.28. There are certain chemicals that should not be mixed because a violent reaction may occur. Each individual is responsible for knowing which chemicals and containers are compatible. Below are common examples of incompatibilities in the Nanofab:
- 11.28.1. Some chemicals such as TCE cannot be used with plastic beakers.
 - 11.28.2. Some chemicals, such as HF, cannot be used with glass beakers.
 - 11.28.3. Acids must always be separated from bases because a violent reaction may occur.
 - 11.28.3.1.1. Acids must also be separated from active metals such as sodium or potassium.
 - 11.28.3.1.2. Further, inorganic acids should be kept away from organic acids.
 - 11.28.4. Bases must always be separated from acids.
 - 11.28.5. Flammables must be kept away from heat, sun, flame, or spark source.
 - 11.28.5.1.1. Also keep flammables away from oxidizers.
 - 11.28.6. Oxidizers must be kept away from flammables and other organic materials.
 - 11.28.6.1.1. Oxidizers should also be separated from reducing agents.
- 11.29. Appendix A contains a more detailed list of specific chemicals that should not be mixed.
- 11.30. General Rules When Working With Chemicals

- 11.30.1. To ensure the Nanofab is as safe as possible, the following procedures should be followed when working with chemicals:
- 11.30.1.1. QNF Wet bench Training is required for all Nanofab users who intend to work with any wet chemistry inside the Nanofab.
 - 11.30.1.2. Nanofab users must read the MSDS before using a chemical in the Nanofab.
 - 11.30.1.3. Nanofab users should be aware of chemicals that must be used in plastic beakers and chemicals that must be used in glass beakers.
 - 11.30.1.4. Beakers, pans and tanks holding chemicals must be labeled with mixture name. Date and owner name must be with beakers left unattended.
 - 11.30.1.5. Nanofab users must always wear appropriate protective equipment in addition to required Nanofab apparel when working with chemicals.
 - 11.30.1.6. Nanofab users should not work with acids or bases in the solvent hoods.
 - 11.30.1.7. Nanofab users should not work with solvents in the acid or base hoods.
 - 11.30.1.8. Nanofab users should make sure that gloves are clean and dry before transferring chemicals to or from the bench.
 - 11.30.1.9. Nanofab users should use only one bottle at a time. Do not open a new bottle unless an existing bottle is completely empty. Pour chemical slowly. Do not let it gulp.
 - 11.30.1.10. Nanofab users should always dispose of chemicals in the designated waste drain, aspirator, or receptacle. Nanofab users should not pour chemicals back into the storage bottle. If Nanofab users pour too much, they should dispose of it appropriately.
 - 11.30.1.11. Nanofab users should put the cap back on each chemical bottle securely. They should rinse and dry the outside of the bottle before returning it to storage. If the bottle is empty, Nanofab users should rinse and properly dispose of bottles.
 - 11.30.1.12. Nanofab users should always exercise extreme caution in handling wet chemistries. Because most chemicals used in the lab look like water, Nanofab users should always assume any liquid is dangerous. In addition, Nanofab users should always dry water off gloves and beakers after rinsing them with water so that others will not mistake the water for a dangerous chemical.
 - 11.30.1.13. Nanofab users should clearly mark the name of the chemicals, the client's name, where someone would contact the client, and when the client expects to return on a clean wiper. Nanofab users should leave this sign next to the chemicals in use.
 - 11.30.1.14. When using hot plates, Nanofab users should check that their beaker is both suitable for hot plate use and smaller than the area of the plate. Nanofab users should never use a Teflon or plastic beaker on a hot plate. Nanofab users should always monitor the temperature of the chemicals on a hot plate with a thermometer.

- 11.30.1.15. Nanofab users should rinse the heavy chemical gloves with DI water and dry them before taking them off. If they become stained, Nanofab users should immediately dispose of them by placing them in a trash receptacle.
- 11.30.1.16. Nanofab users should not wear safety apparel outside of wet bench areas unless working under emergency or HAZMAT cleanup conditions.
- 11.30.1.17. Nanofab users should make sure that all PPE is clean and dry before returning it to storage areas.
- 11.30.1.18. Nanofab users should always clean up their work area before they leave. Beakers should be thoroughly rinsed with DI water, dried and stored right-side up in their appropriate location.
- 11.30.2. Solvent Contaminated Items
 - 11.30.2.1. Wipes, gloves, or other items that have resists or other spin on polymer solutions on them should not be disposed of in the standard trash cans.
 - 11.30.2.2. These polymer solutions will release the solvents into the air for a very long time, filling the room with solvent fumes that the air system can quickly spread throughout the lithography areas. In all the lithography Bays or where solvents are employed, special trash cans attached to building exhaust are to be used for disposing of these items.
 - 11.30.2.3. The trash exhaust prevents the release of the fumes into the room.
 - 11.30.2.4. If a user enters a room and notices a strong solvent smell, it should be investigated immediately, as olfactory fatigue will quickly set in.
 - 11.30.2.4.1. Olfactory fatigue is where the nose stops 'smelling' an odor after being exposed to it for a period of time.
 - 11.30.2.5. The first place to check are the trash cans to see if someone has improperly disposed of a resist covered item.
 - 11.30.2.6. If the source of the odor cannot be located, users should exit the area and contact staff or EHRS.
- 11.31. Chemical Exposures
 - 11.31.1. Any major chemical exposure should be reacted to immediately by using the chemical safety shower.
 - 11.31.2. All clothing should be removed as soon as possible to assist in getting the chemical off of the body. Modesty should not prevent users from doing this. Other users should use the emergency phones to contact EH&S and request medical assistance for a chemical exposure. The injured person should fully rinse the affected area for 15 minutes and then seek medical treatment. If the exposure was to a hydrofluoric acid containing solution, the rinsing should only be for 5 minutes followed by liberal application of Calcium Gluconate Gel to the affected area, followed by medical treatment. Users affected by chemical burns should not worry about any chemical spill, but instead should take care of themselves and allow someone else to deal with the spill. After seeking medical attention for the exposure, the user should contact the Laboratory Manager to

inform them of the incident.

11.32. A Note About Hydrofluoric Acid

- 11.32.1. HF is used primarily to etch silicon dioxide. It is dangerous because of its resemblance to water, it is not painful upon initial contact, it may be absorbed through unbroken skin, it depletes the calcium in the body and destroys tissue and it is potentially lethal. Solutions of less than 10% may take hours before symptoms appear, but any contact is still very dangerous. If skin contact with HF occurs:
- 11.32.2. Nanofab users should immediately Rinse the Affected Skin with water.
- 11.32.3. Nanofab users should Remove all Jewelry and Clothing exposed to HF while rinsing in the safety shower for 5 minutes.
- 11.32.4. Nanofab buddy should Call 511 and demand an Ambulance and HAZMAT team. The buddy should notify the all responders of the MSDS to provide to a doctor in the ER and give a report of the proceedings to the lab manager after the incident.
- 11.32.5. After washing, Nanofab users should NOT Dry Skin.
- 11.32.6. Nanofab users should (with the help of their Nanofab buddy if needed) cover the entire affected area with Calcium Gluconate Gel using a double-gloved hand.
- 11.32.7. Take the gel with you and continuously apply fresh gel on the way to the emergency room and while waiting.
- 11.32.8. HF is the most dangerous chemical in QNF.

11.33. Solid Waste Handling

- 11.33.1. Solid waste that is contaminated with chemicals should be disposed of into the appropriate waste bin; those bins use yellow plastic liners. A small bin located in the spinner benches should be used for solid waste contaminated with the chemicals used in that bench.
- 11.33.2. There are also a number of bins labeled as general waste that use clear liners. Please do not place anything contaminated with chemicals in those bins.
- 11.33.3. Sharps containers can also be found throughout the facility, along with white buckets for glass and silicon disposal.
- 11.33.4. Batteries should be disposed of in containers labeled "Battery Disposal"
- 11.33.5. III-V and II-VI materials should be disposed of in containers labeled "Compound Semiconductor Disposal".

12. Chemical Spill Protocol

12.1. Emergency Response Equipment

- 12.1.1. Spill control kits are placed in several locations around the lab. Bottles of neutralization liquid are also available for use on acid and caustic spills. Emergency showers and eye washes are located around the facility as well. Most chemical burns, particularly in the eyes, should be washed for 15 minutes before seeking

further medical attention. First Aid Kits are available in each Bay. Tubes of Calcium Gluconate Gel are available in the Wet Process Bay for application on hydrofluoric acid burns. This should be applied promptly and is not a substitute for medical attention.

12.2. Nanofab users are required to report all chemicals spills that occur and evacuate the laboratory with all personnel if a hazardous occurs.

12.3. QNF staff and/or EHRS will handle all spills that create a hazardous condition to any QNF occupant.

12.4. A small spill is defined as one that:

12.4.1. Does NOT spread rapidly

12.4.2. Does NOT endanger people or property except by direct contact

12.4.3. Does NOT endanger the environment outside the Nanofab

12.4.4. The volume is less than a ½ gallon of liquid.

12.5. The lab occupant should:

12.5.1. Label the spill and leave someone in charge of alerting others about the spill so that accidents can be prevented.

12.5.2. Contact the Nanofab staff for supervision of the cleanup. The staff may determine that the Nanofab user is capable of cleaning the spill under staff supervision.

12.5.3. If the client is unsure of the severity of the spill, do not hesitate to call EHRS at (215) 898-4453.

12.6. A large spill is defined as one that:

12.6.1. Spreads rapidly

12.6.2. Is toxic

12.6.3. Endangers people or property

12.6.4. Endangers the environment outside of the building and/or is more than a ½ gallon of liquid.

12.7. The lab occupant should:

12.7.1. Call EHRS at (215) 898-4453.

12.7.2. Evacuate the Nanofab, warning others of the spill as they leave.

12.8. Safety Measures for Spill Assessment and Cleanup

12.8.1. Nanofab users and staff should remember that cleaning up a spill may be potentially more hazardous than routinely working with the same substance because you have less control over the environment. Ensure that personal protective equipment is worn.

12.9. Basic Protection For Handling Spills

12.9.1. Eye Protection

12.9.1.1. Safety glasses are required for working in the laboratory or cleaning up spills of hazardous materials. For corrosive and/or reactive materials, goggles or a face shield are also necessary.

12.9.2. Skin Protection

12.9.2.1. When handling wet or dry chemicals, a chemically resistant apron with sleeves should be worn as well as chemically resistant gloves. Gloves are very important as they protect the hands. A pair of heavy nitrile butyl or neoprene gloves and a pair of disposable polyethylene gloves are recommended for each person involved in a cleanup.

12.9.3. Boots or chemically resistant shoe covers may be necessary for large liquid spills.

12.9.4. Since some chemicals may go through even heavy nitrile, butyl or neoprene gloves,

12.9.5. Refer to the MSDS or call EHRS before touching the chemical.

12.10. Additional Precautions

12.10.1. At least two people should be present for every clean up.

12.10.2. Label the area or leave someone in charge of alerting others about the spill so that accidents can be prevented.

12.10.3. If use of a respirator is necessary for the clean-up, contact a member of the Nanofab staff. If a staff member cannot be reached, it is a high-hazard emergency. Nanofab users should alert all others users and evacuate the Nanofab.

12.11. Minor Spill Cleanup Procedures

12.11.1. Nanofab users should alert persons in the area that a spill has occurred. This will ensure that the lab's attention can be focused on the immediate issue - cleanup. Nanofab users should label the area or find someone to alert others about the spill to prevent accidents.

12.11.2. Under staff supervision, the client should turn off any ignition sources in the Nanofab such as burners, motors and other spark-producing equipment. Prevent the spread of contamination and contain any volatile material within a room by keeping doors closed.

12.11.3. Nanofab users should consult the MSDS sheet for the chemical and notify the QNF Staff or EHRS for proper cleaning procedures.

12.11.4. Nanofab users should ensure that they are wearing Personal protective equipment (e.g. goggles, apron, laboratory coat, gloves, shoe covers) based the selection of the equipment on the hazard.

12.11.5. If needed, Nanofab users should use a pH strip to assess the chemical.

12.11.6. Nanofab users should neutralize spills of corrosives before attempting to clean-up the spill.

12.11.7. Absorb liquid spills using the appropriate absorbent pad for the type of chemical spilled. Nanofab users should then place the pad over the spill and draw the free liquid into the pad. Place the used pillows or absorbent materials in plastic

bags for disposal along with contaminated disposable protective equipment (e.g. gloves). Sweep up waste and place in plastic bags for disposal. Do not vacuum any waste or liquids.

13. Equipment Utilization

- 13.1. You must be a Nanofabrication Facility User before becoming a Specific Tool User. Training for all QNF facilities and tools will be conducted by QNF staff or qualified QNF Users. However, final certification may be required by a QNF staff member. Training and qualification are both required to gain User Status for a particular facility or tool. Prospective equipment users need training from QNF staff.
 - 13.1.1. A first-time user is encouraged to observe the equipment operation from qualified group-mates or users prior to official training. Internal users should do a pre-training by observing usage from an already qualified group member if possible.
 - 13.1.2. Formal training for an internal and external user needs to be done with one of the staff in charge of that tool. Training consists solely of observation.
- 13.2. Only Users qualified by QNF technical staff or other qualified QNF user are allowed to use QNF equipment. An official QNF qualification is required even if the person is a qualified user of a similar tool at another facility or institution.
- 13.3. Training includes the observation of facility/tool operation.
 - 13.3.1. Certification is the verification of training by QNF staff (or qualified user) observing the User operate the facility or tool.
 - 13.3.2. Official training will be conducted by assigned QNF staff (or qualified user); please check QNF website for names of staff-in-charge for each tool.
 - 13.3.3. If unable to determine which staff member to contact please email nclay@upenn.edu
- 13.4. Retraining and/or qualification may be required if a User has not used a specific facility for a long period of time. It is the decision of QNF staff to determine the need for retraining and qualification.
- 13.5. Equipment Training and Certification
 - 13.5.1. You must contact a QNF staff member (or qualified user) in charge of the tool in order to complete this step. Qualification consists of operating the tool under the supervision of the QNF staff member (or qualified user) in order to confirm training. Upon the completion of training and qualification, User status will be granted for that particular facility or tool.
 - 13.5.2. Please note that certain facilities/tools require that initial sessions by those with User status either be operator assisted or limited to normal business hours. The QNF staff member in charge of each tool has the final authority over granting

- 13.5.3. User Status and when any initial session requirements are met.
 - 13.5.3.1. Become a General Nanofabrication Facility User
 - 13.5.3.2. Complete training
 - 13.5.3.3. Complete certification
 - 13.5.3.4. Gain access, if applicable, to equipment that requires on-line reservations.

13.6. Please note the following:

- 13.6.1. Only certified Users are allowed to schedule and use equipment
- 13.6.2. An official certification is required even if the person is a certified User of a similar tool at another facility or institution.
- 13.6.3. Retraining and recertification may be necessary if a user hasn't used the specific tool for a long period of time.
- 13.6.4. Do not schedule time for others.
- 13.6.5. You must conform to all rules and procedures regarding use of the specific tool including properly using the tools logbook (if applicable).
- 13.6.6. Bringing in others from your group to "observe" is not allowed without prior permission from the Laboratory Manager. This will be strictly enforced.
- 13.6.7. Users must schedule time prior to operating most equipment. Equipment on-line reservations will be available to all qualified users
- 13.6.8. If necessary it is every user's responsibility to fill in the logbook during and after using equipment
- 13.6.9. It is every users' responsibility to try their best to keep equipment in operating condition
- 13.6.10. It is every user's responsibility to immediately report any unusual occurrences to the engineer in charge
- 13.6.11. Using equipment is generally based on "first-come-first-serve". However, certain priorities may apply according to the agreement among faculty members or scheduling protocols
- 13.6.12. An advance reservation is required for facilities or tools that are listed on the QNF Scheduling Tool.
- 13.6.13. When a User becomes qualified for a facility or tool is on the QNF on-line Scheduling Tool, an account will be created or updated for them to allow for advance time reservation by the User with User Status. If this is their first such qualification they will receive their account information and password from QNF, or via PennKey.
- 13.6.14. Some facilities required initial assistance. In those instances, the QNF staff member must reserve the time.
- 13.6.15. Users are prohibited from scheduling time for another user, even if they are members of the same research group or have the same affiliation.
- 13.6.16. All Users are prohibited from giving out their Scheduling Tool User Name and/or Password for use by other users, or from giving other users access to their PennKey or generic facilities access card for any card reader access controlled QNF

facilities. QNF reserves the right to deny future access to any User in the event of a willful breach of this policy.

13.6.17. It is allowable for a User to have other students/group members enter facilities for observation or training purposes provided that prior arrangements have been made with the Laboratory Manager.

13.6.18. Observation and training both mean watching but not touching! Anyone actually using/operating a QNF tool must be a fully qualified User.

13.7. Facility & Equipment Logs (when applicable)

13.7.1. Users are required to properly and accurately enter all information requested in facility/tool logbooks.

13.7.2. Users are required to PRINT their full names (first and last) in all QNF logbooks. Please no first names only or nicknames etc.

13.7.3. Users are required to enter in all QNF logbooks the time they entered and left the facility.

13.7.4. Users are required to note any problems or irregularities with the facility or tool's operation during their session in the logbook. These notes alert subsequent Users to instrument status.

14. Nanofab Infractions

14.1. From time to time, people will have other things on their mind and unintentionally do something they really should not do. Most people do not mind a friendly reminder now and then. It is up to the users to keep the Nanofab operating smoothly, and as long as everyone cooperated then the chances of ruined projects, injuries, and problems in general are greatly reduced. If anyone has a problem with being politely told about something that may endanger somebody, tell the staff about it and we will take care of the problem.

14.2. Using QNF is a privilege, not a right. That privilege comes with responsibilities. Users are written up (for a warning or a violation, at staff's discretion) every time they fail to follow the Facility protocols. The nature and severity of the violations determine whether the access is re-instated or not.

14.3. The following describes proper Nanofab policies that users must follow at all times. Failure to do so is a violation, and the penalty for the violation is also listed below. Users must arrive at the equipment site promptly, as a delay of greater than 30 minutes will count as a "no-show". If a user realizes that he/she will not require using the equipment he/she reserved, the reservation must be cancelled before the hour it is reserved for. It is encouraged that users cooperatively share equipment usage time. Users are not allowed to schedule equipment time for another user in their own account name. This means that, you should not sign up for equipment in your name

with the intent of giving the time to another user, even though it is a member of your group.

14.4. Below are common violations, penalties and explanations associated with various Nanofab infractions. Please note these examples are included for reference, but not limited to the range of infractions that may be encountered.

Violation: Granting access to an unauthorized user to use equipment or enter the facility.

Penalty: Suspension from the Nanofab for up to three weeks.

Explanation: Without consent of the Laboratory Manager, no user can grant access to an unauthorized user to use equipment or the facility without his/her constant supervision. The authorized user must be present the entire time the other user wants to use that equipment.

Violation: Using equipment with someone else's access privileges without being an authorized user and/or not under supervision.

Penalty: Suspension from the Nanofab for up to three weeks.

Explanation: A user is not allowed to use equipment without being an authorized user for the equipment. He/she can only use the equipment under the full supervision of an authorized user.

Violation: Allowing an authorized/unauthorized user to run equipment under your name without supervision.

Penalty: Suspension from the Nanofab for up to three weeks.

Explanation: No user can grant access to another user, authorized or unauthorized, to use equipment without his/her constant supervision. The authorized user who has access to the equipment must be present at the equipment the entire time the other user wants to use that equipment.

Violation: Using equipment reserved for another user.

Penalty: Suspension from the Nanofab for up to three weeks.

Explanation: A user is not able to login to any equipment reserved by another user for the first 30 minutes of the first hour the equipment is reserved. If the person who reserved it does not show up in the first 30 minutes, any other authorized user can use the machine after that time.

If a user's run exceeds his/her scheduled time, the next user who has reserved the equipment should reach a compromise with the previous user. The machine belongs to the user who reserved it, and it is entirely his/her decision to allow or disallow the previous user from using it. The user should however be careful in allowing the previous user to continue using the equipment, as he/she faces the risk of violating a Nanofab policy. Also, after 30 minutes is up, if another user finds the equipment not in use, and begins using it, the machine belongs to this user. Therefore, if a user allows the previous user to use the

equipment, he/she must log into the equipment after logging out the other user. The user should then be around the equipment to prevent another violation.

Violation: Using equipment when it is undergoing maintenance and is marked not to be used or “System/Machine Down”.

Penalty: Suspension from the Nanofab for three weeks.

Explanation: Under no circumstances is a user allowed to perform any maintenance on any equipment. Any abnormalities while using the equipment must promptly be reported to the QNF Staff. When a machine is undergoing maintenance/repairs, users must be cooperative and patient. No user is allowed to use equipment in a non-workable state, or when it is undergoing routine maintenance.

Violation: Being logged in equipment for longer than the equipment time limit (running into someone else’s time).

Penalty: First Offense: Written warning. Second Offense: One-week suspension from Nanofab. Third and Subsequent Offenses: One week suspension from Nanofab each time. If the equipment is not reserved by another user, you can continue to use the equipment. If you are exceeding the equipment time limit for usage, you should log out, and log back in. This resets the timer for the equipment login.

Violation: Failure to record use in logging computers or reporting use in logbooks.

Penalty: First Offense: Written warning. Second Offense: One-week suspension from the Nanofab. Third and Subsequent Offenses: One week suspension from Nanofab each time.

Violation: Leaving chemicals without proper labels

Penalty: The mislabeled chemical will be disposed of properly. The user will be issued a written warning. Repeat Offenders: One-week suspension from Nanofab.

Explanation: All chemicals left unattended must be properly documented by the use of these chemical warning forms. This includes everything, including water, which is left unsupervised at the fume-hood, hotplate, or any other location for any period of time.

Violation: Not wearing proper safety equipment at a wet bench.

Penalty: First Offense: Reminder to put on proper safety equipment. Second Offense: Written warning. Third Offense: One week suspension from the Nanofab. Fourth Offense: One-month suspension from Nanofab. Subsequent Offense: One semester suspension from Nanofab.

Violation: Unauthorized entry into the Nanofab following another user or allowing a user to enter the Nanofab behind you.

Penalty: Suspension from the Nanofab for up three weeks.

Explanation: Each user should scan/swipe individually to enter the Nanofab level, and get in the gowning area. No one should follow another user into the Nanofab. This is to prevent the entrance of unauthorized users into the Nanofab.

Violation: Damage to equipment.

Penalty: The charges that the individual responsible for the damage will incur will be determined on a case-by-case basis.

Violation: Not following proper gowning and de-gowning procedures.

Penalty: First Offense: Demonstration of proper gowning and de-gowning procedures. Second Offense: Written warning. Subsequent Offense: One-week suspension from the Nanofab each time.

Violation: Removing supplies and/or equipment from Nanofab.

Penalty: Suspension from the Nanofab for three weeks.

15. Appendix A: Common Acids & Bases Utilized

15.1.	Chemical Type	Chemical Formula	Concentration
15.2.	Acids and Oxidizers	Acetic Acid	CH ₃ COOH 95%
15.3.		Hydrofluoric Acid	HF 49%
15.4.		Hydrochloric Acid	HCL 36%
15.5.		Nitric Acid	HNO ₃ 68%
15.6.		Phosphoric Acid	H ₂ PO ₄ 85%
15.7.		Sulfuric Acid	H ₃ SO ₄ 96%
15.8.		Hydrogen Peroxide	H ₂ O ₂ 30%
15.9.	Aluminum Etch	80-15-3-2 Phosphoric Acid	80%
15.10.		Acetic Acid	15%
15.11.		Nitric Acid	3%
15.12.		Water	2%
15.13.	NANO-STRIP	Sulfuric Acid	90%
15.14.		Peroxymonosulfuric Acid	5%
15.15.		Hydrogen Peroxide	5%
15.16.	BOE (Buffered Oxide		
15.17.	Etch)	NH ₄ -HF	50%-10%
15.18.	Bases	Ammonium Hydroxide	NH ₄ OH 25%
15.19.		Ammonium Fluoride	NH ₄ F 40%
15.20.		Potassium Hydroxide	KOH 45%
15.21.		Sodium Hydroxide	NaOH 50%
15.22.		Tetramethylammonium	
15.23.		Hydroxide	(CH ₃) ₄ NOH 25%
15.24.	Solvents	2-Propanol	CH ₃ CHOHCH ₃ 100%
15.25.		Acetone	CH ₃ COCH ₃ 100%
15.26.		Chlorobenzene	C ₆ H ₅ Cl 100%
15.27.		Methanol	CH ₃ OH 100%
15.28.		Toluene	C ₆ H ₅ CH ₃ 100%
15.29.		Trichloroethylene	C ₂ HCl ₃ 100%
15.30.		Xylene	C ₆ H ₄ (CH ₃) ₂ 80-90%

16. Appendix B. Common Corrosives Utilized

- 16.1. Chemical Type Chemical
- 16.2. Corrosives Ammonium Fluoride
- 16.3. Ammonium Hydroxide
- 16.4. Ammonium Hydroxide
- 16.5. Buffered Oxide Etch (BOE)
- 16.6. Hydrochloric Acid
- 16.7. Aluminum Etch 80-15-3-2
- 16.8. Hydrofluoric Acid
- 16.9. Phosphoric Acid
- 16.10. Potassium Hydroxide
- 16.11. Resist Developer
- 16.12. Sulfuric Acid

17. Appendix C. Incompatible Chemicals

- 17.1. Chemical Incompatible with:
- 17.2. Acetic Acid Nitric Acid, Ethylene Glycol, Peroxides,
- 17.3. Permanganates
- 17.4. Ferric Chloride Aluminum
- 17.5. Hydrogen Peroxide Copper, Chromium, Iron, Alcohols, Acetone, Organics
- 17.6. Mercury Ammonia
- 17.7. Nitric Acid Photoresist Developer, Acetic Acid, Flammable
- 17.8. Liquids, Flammable Gases
- 17.9. All Acids (ex. Hydrochloric, hydrofluoric) All Bases (ex. Sodium cyanide,
potassium hydroxide,
- 17.10. sodium hydroxide)
- 17.11. Oxidizers (ex. Permanganates, inorganic peroxides,
- 17.12. Persulfates, perchlorates)
- 17.13. Flammables, organic materials, reducing agents (ex.
- 17.14. Zinc, alkaline metals, formic acid)
- 17.15. Water Reactives (sodium, potassium, metal hydrides,
- 17.16. hydrolysable halides) Water
- 17.17. NANO-STRIP Solvents
- 17.18. Sulfuric Acid Solvents

18. Version History

Revision	Date	Author	Changes
0.0	05/03/14	N. Clay	Original draft
0.1			
0.2			