AggieFab Manual

(Updated 30 June 2021)

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1 Accessing AggieFab

1.1 AggieFab Access Protocol

- AggieFab uses the iLab system to handle all services (membership, training, etc).
- To begin the process of becoming a user, please visit the following web address: https://aggiefab.tamu.edu/become-a-user/
- Safety Training
  All users must receive basic safety training through safety training courses offered by TAMU as well as various AggieFab specific trainings. For more details, see Section 2.
- Authorization request and receiving card key access
  Upon finishing all safety training, the advisor should request AggieFab access by sending an email to admin@aggiefab.tamu.edu. The user will be asked to submit all safety training documents and the signature page in Section 3 as a PDF through the iLab system. Upon confirmation and approval, the user will receive card key access to GERB. To receive card key access to AggieFab, the user needs to be qualified for at least one instrument in AggieFab (see Section 4).
- Personal protection equipment (PPE)
  User will receive cleanroom garments (hood, coverall, boots, and safety glasses) from AggieFab staff. Other PPE, such as acid gloves, acid aprons, and face shields are available inside the cleanroom.
  All users are required to follow the AggieFab Rules outlined in this document. Failure to do so may result in losing access to AggieFab.

Please note that the following items are prohibited in AggieFab:

- Food and drink
- Regular paper, wood, plywood, cardboard boxes, and foam products
- Pencils and erasers

Only cleanroom notebooks and ball point pens are allowed. If you need to bring permissible items into AggieFab for your experiments, you may contain them in a Ziploc bag, zippered plastic bag, or plastic tote.

1.2 Operating hours

Normal Operating Hours: Monday – Friday, 8:00AM – 5:00PM

After-Hours Operation: After-hours access (24/7) is granted on a subjective basis to users who have been working in the lab consistently (e.g., at least every other week) for at least 6 months and have demonstrated they can handle tools and processes responsibly. Those who use the lab inconsistently will be considered on a case by case basis. There must be at least one other user in the lab with you while you are working after hours to ensure the safety of both users. It is also strongly recommended that users finish their work between 8:00 AM and 11:00 PM. Please limit the use of the AggieFab outside of these hours to minimize the safety risk. If the need to work after 11 PM arises, prior approval should be obtained by providing a detailed account and explanation. Users without after-hours privileges are allowed to accompany 24/7 users within their research group into the lab. The 24/7 user is to be held responsible for the non-24/7 user in case any wrongdoing occurs.

Furnace usage after 11 PM (such as having to take out samples due to long run times) is excluded from the approval requirements outlined above, but notification should still be sent to admin@aggiefab.tamu.edu.

1.3 Internal Visitor Access Guidelines

- Current AggieFab PIs bringing a visitor for a lab tour will not need to get approval.*
- Cleanroom users (students, postdoctoral researchers, and technicians) bringing a visitor for a lab tour on behalf of their PI must have the PI submit a written request (email) to the AggieFab Manager for approval prior to the tour.*
- No other personnel will be allowed to enter the facility.
- If exception is needed for special circumstances, the PI will have to submit a written request (email) to the AggieFab Director. The case will be discussed by the AggieFab Committee, and will require final approval by the Director.
- All visitors to the AggieFab must sign the Liability Waiver prior to entry. See page 23.

All other visitors not affiliated with Texas A&M will need to contact Hanna Prichard (hprichard@tamu.edu) for more details on access

2 AggieFab Safety

Safety is extremely important while conducting experiments, and any blatant disregard of safety guidelines will result in immediate expulsion from AggieFab.

2.1 General Safety Information

- No eating or drinking is allowed in the lab.
- Proper attire to enter the lab includes close-toed shoes, long pants, and a top with sleeves. While in the lab, you must wear a hairnet, nitrile gloves, and shoe covers under your cleanroom coverall, hood, and boots.
- Safety glasses with side shields are required.
- This is a shared user space. Keep your work area neat and orderly upon finishing your experiment by cleaning up any mess you may have made.
- Put all chemicals or tools back where you found them.

2.2 Safety Precautions

- If you are unsure or don't know, call the lab manager or equipment trainer.
- Know the locations of emergency showers, eyewash fountains, fire extinguishers, respirator masks, first aid kits, and safety data sheets (SDS) (*See* Appendix I).
- If an acid or base splashes into a person's eye, flush the eye profusely with cold water for 15 to 20 minutes using the eyewash station. It is imperative that the eye be held open during the rinse. After rinsing, seek immediate medical treatment.
- If an acid or base splashes onto your skin, rinse immediately in cold water for 15 to 20 minutes. Then notify the lab manager.
- If an acid or base spills on your clothing, remove the clothing immediately.
- For Hydrofluoric Acid (HF) burns, apply Calcium Gluconate gel immediately (*See* Appendix II).

2.3 Training Requirements

Complete the following training by visiting https://ehs.tamu.edu/programs/laboratory-safety/

Introduction to Laboratory Safety (online course number: 2114106)

On-line Hazard Communication Training (online course number: 11020)

Visit 'Single Sign On' (**https://sso.tamu.edu/**) via HR Connect to complete other certified general safety Trainings via TrainTraq.

If you do not receive a certificate, contact David Breeding of the Engineering College Safety Office at **safety@tees.tamus.edu** with following information to receive the training certificates.

- Student's full names as registered
- UIN number
- Affiliation
- Laboratory assignment by building & room number
- Name (s) of actual safety courses completed
- Name & email of their professor or supervisor
- Their statement under the *Aggie Honor Code*, that they have thoroughly studied and completed the course materials and their pledge to apply this knowledge to reduce risk for themselves and others.

2.4 General Handling of Laboratory Chemicals

A number of strong acids, solvents, and bases are used in the lab. Users should be aware of the characteristics of each chemical used in the laboratory as well as the general handling and safety guidelines listed below. For more detailed information on the chemicals and materials used, the SDS is available through the AggieFab website (aggiefab.tamu.edu) under the "Training" tab.

Bringing New Chemicals or Materials into the AggieFab

- If you don't see the chemical you want to use in the cleanroom in the SDS folder/in the "Approved Materials" section of this manual, you are not allowed to bring it in.
- If you would like to bring any new chemicals or materials, the user or PI must submit a written (e-mail) request to the AggieFab manager with the name of the chemical, a PDF of its safety data sheet (SDS), and a description of the process it will be used for.

Safety Precautions

- Always wear proper protective clothing, including rubber gloves and safety glasses.
- Always check rubber gloves before using them. Never touch your face or body while wearing rubber gloves and always rinse gloves off before removing them. To check for leaks, inflate the glove using the N2 nozzle and see if the glove can hold the inflated state.
- All chemicals, especially acids, bases, and strong solvents, should always be used in an exhausted fume hood.
- The fume hood cover/sash should always be in the "down" position to prevent fumes from being released into the room.
- Photoresist-related chemicals should be used in well-ventilated areas.
- Always label beakers and do not let beakers of unused chemicals accumulate.
- Rinse empty beakers thoroughly by placing them under a running water faucet for several rinses and then placing them top down in the drying oven.
- Always start with clean beakers that have been placed top down in the drying oven or on the storage shelves.
- Never pour excess chemicals back into the containers. Pour excess chemicals into the appropriate waste container. When finished, return containers to their storage locations immediately.
- All chemicals should be disposed of according to the guidelines set forth by the lab. See Appendix VI.
- Chemicals, such as solvents, some acid mixtures, etchants, developers, strippers, and bases must be poured into their designated waste containers for later pickup.
- Always assume unknown liquid spills and beakers with unknown substances are dangerous and treat them accordingly.
- When in doubt about the proper procedure, always ask a staff member.

Handling Solvents

- Solvents are volatile, and their fumes are highly flammable. Clearly, flames should not be allowed in the lab. If fumes from solvent in a beaker should happen to ignite, cover the top of the beaker with another larger beaker or container to extinguish the flames.

Handling Acids and Bases

- When working with strong acids, a face shield, acid apron, and acids gloves should be worn for maximum protection. Never pour water into acids as this can cause a reaction, which will splash acid everywhere. Always pour acids slowly into water.

- Always pour acids carefully to avoid splashing. Wipe off any excess from the bottle and return it to its proper storage area after use.

Safety Information

- Sulfuric acid is extremely corrosive and toxic to body tissues. It will rapidly attack the skin and can cause severe burns and blistering.
- Nitric acid can also destroy tissue and cause burns. Nitric acid leaves a characteristic yellow stain on the skin.
- Phosphoric acid should not be heated to the boiling point since the fumes are toxic. It will cause burns if it contacts the skin.
- Ammonium hydroxide is a powerful base that can cause severe burns. It should always be used with adequate ventilation.

Handling Hydrofluoric acid (HF)

- Hydrofluoric acid can produce severe skin and deep tissue burns that are slow in healing. It is more dangerous in that burns may not be noticed until sometime after the exposure and the burns can be extremely painful. Please see *Appendix II* for detailed handling information.

Handling Piranha Solution

- Piranha solution is a mixture of sulfuric acid (H_2SO_4) and hydrogen peroxide (H_2O_2), used to clean organic residues off substrates. Please see *Appendix III* for detailed handling information.

Handling TMAH

- The use of TMAH is only permitted with prior approval of the AggieFab Lab Manager. The request must be in writing (email), and all safety equipment must be provided and on hand during use. TMAH may only be used during normal business hours and when the technical staff is present.
- Note that most photoresist strippers and developers contain TMAH.
- TMAH is considered a health risk, especially for women of child bearing age.

Solution Mixing Guidelines

- Use a face shield rather than goggles. Mix chemicals under an exhaust hood. Never peer into the top of a beaker - always view it from the side.
- Pour chemicals slowly and make sure you have the correct chemicals.
- Never pour excess chemicals back into the containers. Pour excess chemicals into the appropriate waste container. When finished, return containers to their storage locations immediately.

2.5 Furnace Safety

Furnace temperatures frequently exceed 1100 °C in the flat zone of the tube. The following procedures should be observed when working with a furnace.

- The quartz tube of the furnace glows (orangish) when heated. Staring at this for long periods of time may damage your retinas.
- Keep the open end of the furnace tube covered as much as possible to prevent diffusion of atmospheric gases.
- Although the sides of the furnace are generally cool to touch, the quartz ends may be quite hot.
- When removing the end cap, use a thick cloth or glove for protection. When a push rod is removed from the furnace, the end will be too hot to touch for at least five minutes.
- Glass components on the furnace setups are actually quartz, which means they are quite expensive. Handle them carefully!
- Gases flow continuously through the furnaces.

2.6 Electrical Safety

The electrical hazards in the lab are comparable to those of other electrical engineering laboratories with a few notable exceptions.

- The probe stations can produce several hundred volts and lead to fatal shocks. Keep the curve tracer OFF while connecting leads to the device being tested.
- Always ground the Lesker Electron Beam Evaporator using the ground rod to the left of the tool. See the tool's Standard Operating Procedure for detailed information.

- Equipment such as furnaces and mask aligners may have high-voltage circuitry behind protective panels. Do not attempt to work on this circuitry!

3 Signature Page

- **I have completed all required safety trainings as outlined in this AggieFab manual.**
- **I have read all safety instructions, including the appendices, and agree to observe all safe lab practices.**

Name of Student (print): _____

Supervisor (Name): _____

Student's Address:

Phone:

Email:

Person(s) to be notified in the event of an accident of emergency:

Name (print): _____ Relationship: _____

Phone (home): _____Phone (work): _____

Address:

Signature: _____

Date: _____

UIN: **NetID:**

Expected Graduation Date:

4 AggieFab Equipment Training

In order to become eligible to use the equipment in AggieFab, the user must go through the following training procedures.

4.1 Trainers

- Each piece of cleanroom equipment has one or more designated trainers. The list of trainers can be found on the AggieFab website under the "Training" tab.
- The trainers are divided into 2 groups: those who can provide the initial 1 or 2 training sessions and those who are authorized to do the final check-off training.

4.2 Equipment Training Protocol

- To receive equipment training, the user has to contact trainers for that particular equipment and schedule a training session. The tab for the list of trainers can be found on this page: https://aggiefab.tamu.edu/training/.
- The user is required to read the standard operating procedure for the equipment that is available on AggieFab website (here https://aggiefab.tamu.edu/equipment/) before coming to the training session.
- During the first training session, the new user demonstrates the proper usage of the equipment to the trainer. The first and second training sessions must occur on different days and may be by different trainers, depending on the piece of equipment. During the second training session, the new user demonstrates the proper usage of the equipment to the trainer.
- If the second training session is the final training session (e.g., for less complicated pieces of equipment), then the second training session is considered the final check-off session and must be done by trainers who can provide check-off training and are generally members of AggieFab staff. The final check-off training may be done by a different trainer than the initial training sessions.

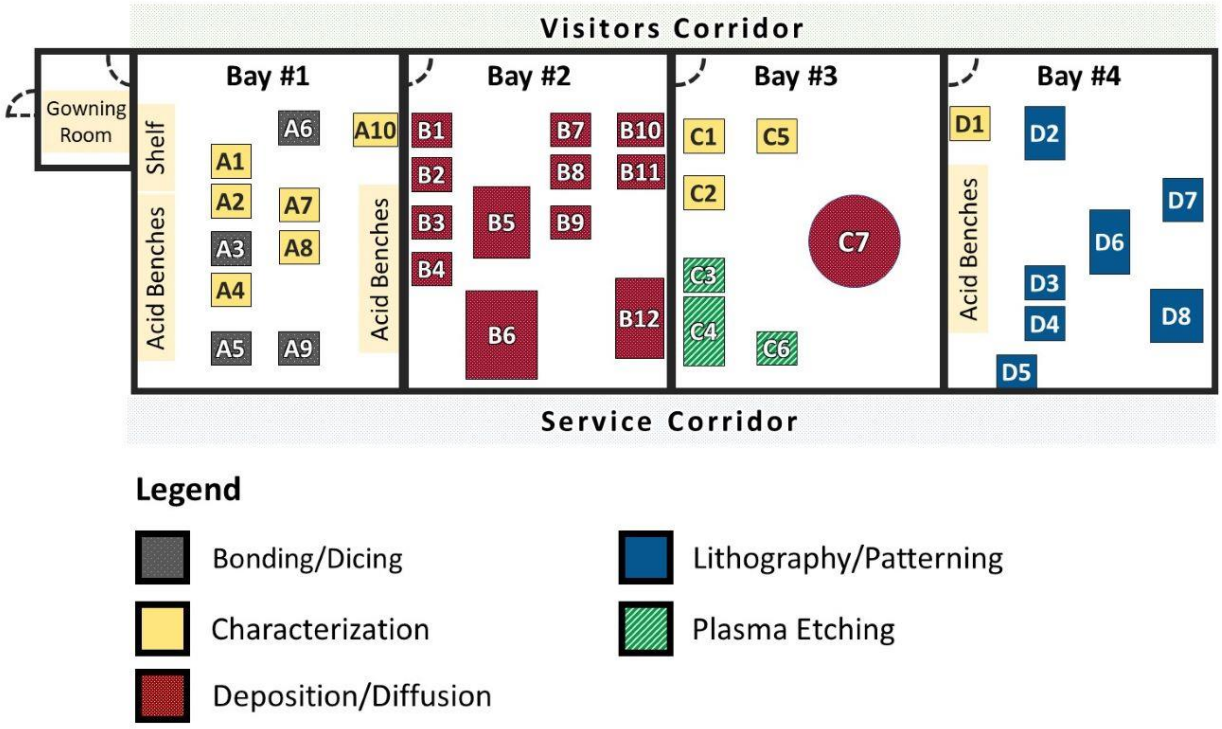
- After this form is filled out by all trainers, the check-off trainer notifies the AggieFab lab manager and program specialist by emailing the form or providing a hard copy. The program specialist will then provide reservation permissions in iLab and building access, if needed. The lab manager makes the final decision on whether the user is authorized to operate the equipment on their own and retains the right to revoke the privilege if a cause for doing so arises.
- All trained AggieFab users must have access to iLab and complete the required safety classes. They must demonstrate to the check-off trainer or AggieFab lab manager how to properly wear cleanroom garments and where chemical spill and first aid kits are located in AggieFab.
- If the trainer fails the user during the check-off session, the user needs to practice further either with the trainer or other authorized equipment users, and requests another check-off session.

4.3 Equipment Usage Protocol

- All authorized equipment users are required to fill out the equipment log book if it is located next to the equipment. Failure to use the log books will result in suspension of access to the equipment.
- All users are required to abide by the equipment operating manual posted on the AggieFab website. Failure to do so may result in losing equipment access.

5 Appendices

5.1 Appendix 1: AggieFab Floor Plan and Equipment List



Please see a full description of the equipment at: https://aggiefab.tamu.edu/equipment/.

5.2 Appendix 2: Hydrofluoric acid (HF) Handling Manual

HF will penetrate the skin and attack underlying tissues. HF may produce severe ocular and dermal injury, as well as acute life-threatening systemic toxicity with minimal external tissue damage. Both liquid and vapor can cause severe burns, which may not be immediately painful or visible.

1. Proper Protection Equipment

The handling of HF solution requires special protection equipment in addition to the regular clean lab coat, safety glasses and nitrile gloves for standard Yellow Room protection. The additional protective equipment includes the followings:

- Full face shield
- Heavy duty neoprene rubber gloves (standard purple nitrile gloves used in the cleanroom will not provide sufficient protection)
- Acid apron to wear on top of the cleanroom garments

2. Proper HF Solution Handling

- All users must thoroughly read and understood the attached Hydrogen Fluoride Emergency Protocol.
- HF is a glass etchant; only use plastic labware to contain HF, not glass beakers.
- Personal protective gear is imperative and required as noted above
- Do not attempt an experiment if calcium gluconate cannot be found. Check calcium gluconate before commencing any experiment to ensure that they have not passed their expiration dates.

3. Waste Disposal Procedures

- (Preferred method) Use the aspirator to remove the HF from the beaker. Follow with DI water to dilute the acid and clean the aspirator's tip.
- HF can be poured down any white polypropylene wet bench with DI water and a sink with an acid drain. Slowly and carefully pour the HF while following with DI water to dilute.

4. Accident / Injury Response

- Apply first aid as required.
- Notify clean room staff immediately.

- In the case of skin contact first aid must be started within seconds. If the skin contact is local, immediately remove any contaminated clothing and wash the area with water for 15 minutes, then apply generous amounts of calcium gluconate gel to the area. Gently massage the gel into the contaminated areas while using gloves. White specks appearing around the burned region indicates the formation of calcium fluoride and that the gel is working. Gently apply the gel for 15 minutes and reapply when the pain flares up.
- If larger amounts of HF are spilled, or if HF is spilled in a difficult area to wash, remove clothing and proceed immediately to the nearest safety shower. After showering apply the calcium gluconate gel. It is important to realize that calcium gluconate gel WILL NOT adequately neutralize the effect of HF on tissue by itself. Rinsing with water prior to application of the gel is critical. In case of eye contact, rinse the eyes with large amounts of water for a minimum of 5 minutes and seek medical attention. Do not apply calcium gluconate gel to the eyes.
- If HF is ingested, contact medical help. Do not induce vomiting. If vomiting occurs naturally, help the person so they do not choke on the vomit. If HF vapor is inhaled, move the person to fresh air and seek medical attention at once.

5. Spills

- A HF spill kit is located in the chemical storage area. **Note:** Spill kits that contain Floor-dri, kitty litter, or sand should NOT be used because HF reacts with silica to produce a toxic gas.
- If HF is spilled outside a chemical fume hood, evacuate the area, close the doors, post the area to prevent others from entering, and call staff.
- Small spills inside a fume hood can be cleaned by lab staff if they have had proper training on HF cleanup and waste disposal.

6. Supply and Storage

- HF acid and BOE are stored under the wet bench in Bay 4 labeled “Acids/Etchants”.
- SDS is located on the AggieFab website under the “Training” tab.

TEXAS A&M UNIVERSITY ENVIRONMENTAL HEALTH & SAFETY
CHEMICAL FACT SHEET

HYDROFLUORIC ACID

HEALTH RATING
4 = EXTREME

CONTACT RATING
4 = EXTREME

HYDROGEN FLORIDE; HF; FLUOROHYDRIC ACID; FLUORIC ACID; HF IN AQUEOUS SOLUTION

Hydrofluoric acid (HF) is an extremely corrosive acid used for many purposes including mineral digestion, surface cleaning, etching, and biological staining. The unique properties of HF make it significantly more hazardous than many of the other acids used on campus.

SAFETY PRECAUTIONS

- **Ventilation**
Concentrations of HF greater than 5% should always be handled inside a properly functioning chemical fume hood.
- **Eye Protection**
Always use chemical goggles together with a face shield when handling concentrated HF.
- **Body Protection**
Wear a laboratory coat with a chemical splash apron made out of natural rubber, neoprene, or viton. Never wear open-toed shoes or shorts when handling HF.
- **Gloves**
Wear medium or heavy-weight vitron, nitrile, or natural rubber gloves with a pair of nitrile gloves underneath to protect against leaks.
- **Eyewash/Shower Combination**
Required to be nearby and accessible.

EYE AND SKIN EXPOSURE

- Contact with eyes may result in blindness or permanent eye damage.
- HF readily penetrates human skin, allowing it to destroy soft tissues and decalcify bone.
- Chemical burns from HF are typically very painful and slow to heal.
- Skin exposure to highly concentrated HF (approximately 50% or greater) immediately results in serious and painful destruction of tissue.
- In concentrations of 20-50%, the burn becomes apparent 1-8 hours following the exposure; and in concentrations of less than 20%, symptoms may be delayed for as long as 24 hours.
- Not only can skin contact with HF cause burns, but systemic fluoride poisoning may also result.

INHALATION OF VAPOR

- Inhaling HF vapors can cause severe respiratory damage, including severe irritation of the nose, throat, and lungs.
- Delayed reactions up to and including fatal pulmonary edema (fluid build-up in the lungs) may not be apparent for hours after the initial exposure.
- Employees' exposure to airborne concentrations of HF should be limited to an average of 3 ppm over an 8-hour work day.
- Concentrations of 10 to 15 ppm will irritate the eyes, skin, and respiratory tract. At concentrations of 30 ppm HF is immediately dangerous to life and health, and may have irreversible health effects.
- At concentrations above 50 ppm, even brief exposure may be fatal.

CHRONIC EXPOSURE

- The chronic inhalation of hydrofluoric acid can cause irritation and congestion of the nose and throat, and bronchitis.
- Studies have found that HF inhalation may also damage the liver and kidneys.
- Fingertip injuries from HF may result in persistent pain, bone loss, and injury to the nail bed.
- Occupational studies of women exposed to fluoride have identified HF as a possible teratogen (reproductive hazard).
- Long-term or chronic exposure to hydrofluoric acid may result in fluorosis; a syndrome characterized by weight loss, bone embrittlement, anemia, and general ill health.

Because of the ability of HF to produce severe delayed tissue damage without necessarily producing pain, all skin, eye, or tissue contact with HF should receive immediate first aid and medical evaluation, even if the injury appears minor or no pain is felt.

TRAINING

- Employees who handle HF MUST receive documented training on the hazards of HF and what to do in the event of an exposure or a spill.
- A Material Safety Data Sheet (MSDS) on HF should be kept in the immediate work area where HF is used.

SPILLS

- If HF is spilled outside a chemical fume hood, evacuate the area, close the doors, post the area to prevent others from entering, and call 911 (9-911).
- Small spills inside a fume hood can be cleaned by lab staff if they have had proper training on HF cleanup and waste disposal.
- Note: spill kits that contain Floor-dri, kitty litter, or sand should NOT be used because HF reacts with silica to produce a toxic gas.

STORAGE

- Glass, metal, and ceramic containers are NOT compatible with HF. Store in polyethylene or Teflon containers.
- Never store HF with incompatibles such as strong bases (i.e. Sodium Hydroxide and Potassium Hydroxide), or ammonia and other alkaline materials.

WASTE

All HF waste, including contaminated clothing and gloves used to apply calcium gluconate gel should be labeled and disposed of as "Hazardous Waste".

FIRST AID

- **Skin contact** - Immediately (within seconds) wash affected area for a minimum of 5 minutes. Have someone call 911 (9-911 from a campus phone). Remove all contaminated clothing. Using gloves, massage calcium gluconate gel into the affected area. Re-apply gel every 15 minutes until assistance arrives or pain completely stops. If calcium gluconate gel is not available, wash affected area for at least 15 minutes or until medical assistance arrives.
- **Eye contact** - Immediately (within seconds) rinse eyes for a minimum of 30 minutes. Do NOT apply calcium gluconate gel to eyes. Have someone call 911 (9-911).
- **Ingestion of HF** - Dilute the acid by drinking large quantities of milk (preferable) or water. Have someone call 911 (9-911). Do NOT induce vomiting.
- **Inhalation** - Immediately move to an area with fresh air. Call 911 (9-911).

Note: Provide medical personnel with an MSDS sheet for HF.

If you work with HF, please contact EHS Occupational Health Program for a pre-exposure medical consultation.
ehsd.occ.health@tamu.edu

5.3 Appendix 3: Piranha Solution Handling Manual

Piranha cleaning is used to remove organic residues from substrates. Acid piranha is a self-starting reaction which is extremely exothermic.

NOTE: AggieFab staff produced a detailed SOP for the production of piranha solution that is provided during piranha training. This is an overview for general AggieFab users.

1. Proper Protection Equipment

The handling of Piranha solutions requires special protection equipment in addition to the regular clean room gown, safety glasses and nitrile gloves for standard Yellow Room protection. The additional protective equipment includes the following:

- Full face shield
- Heavy duty neoprene rubber gloves (standard purple Nitrile gloves used in the Yellow Room will not provide sufficient protection)
- Acid apron to wear on top of the cleanroom garments

2. Proper Piranha Solution Handling

- Whenever handling Piranha, only use glass containers (preferably Pyrex). Containers used during the experiment must be very clearly labeled. All work must be done under the fume hood.
- Mix the solution in the chemical hood with the sash between you and the solution. Wear full protection gear (face shield, acid apron, acid gloves) as described above.
- When preparing the piranha solution, always add the peroxide to the acid. The H_2O_2 is added immediately before the etching process because it immediately produces an exothermic reaction with gas (pressure) release. If the H_2O_2 concentration is at 50% or greater, an explosion could occur. The H_2O_2 currently in use in AggieFab is 35%.
- A 3:1 H_2SO_4:H_2O_2 is generally used. Ask your trainer for more information on different mixture ratios.
- Piranha solution is very energetic and potentially explosive. It is very likely to become greater than 100 °C.
- Substrates should be rinsed and thoroughly dried before placing them in a piranha bath.

- Piranha etch is used to remove photoresist residue, acetone residue, and native oxides, not the compounds themselves.
- Adding any acids or bases to piranha or spraying it with water will accelerate the reaction. This includes photoresist, which is a strong base.
- Mixing hot piranha with organic compounds may cause an explosion. This includes acetone, photoresist, isopropyl alcohol, and nylon.

3. Piranha Waste Disposal

- The primary hazard from storage of piranha etch waste is the potential for gas generation and over pressurization of the container when the solution is still hot. Never store any piranha solutions. Piranha stored in a closed container will likely explode.
- After complete cool down of the solution (1-2 hours after adding the H_2O_2), use the aspirator to dispose of the piranha and follow the DI water down the drain.

4. Emergency Procedure

- Any exposure to Piranha or its vapor is severe and dangerous. The victim should be removed from the contaminated area, placed under a safety shower while the cleanroom staff are contacted.
- All contaminated clothing should be removed immediately with appropriate gloves and safely discarded.
- In case of contact with the skin, the affected area must be immediately rinsed with large amounts of water from the emergency shower for at least 15 minutes.
- In case of contact with the eye, irrigate the eye for at least 15 minutes at the eyewash, keeping the eyelids apart and away from eyeballs during irrigation. Place ice pack on eyes until reaching emergency room.
- Inhalation of hot or cold Piranha vapors will severely burn the upper respiratory tract.
- Conscious persons should be assisted to an area with fresh, uncontaminated air. Seek medical attention in the event of inhalation; coughing or tightness in the chest may result. Symptoms may be delayed.

5. Supply and Storage

- Sulfuric acid is stored under the wet bench labeled “Acids/Etchants” and hydrogen peroxide is stored under the wet bench labeled “Oxidizers”.

- SDS is available online on the AggieFab website.

5.4 Appendix 4: Liability Waiver Form

ACCIDENT WAIVER AND RELEASE OF LIABILITY AND HOLD HARMLESS FORM

Aggie Fab Laboratory Tour

Date of Activity or Event: _____

Check One:

On Campus visitor _____
Off campus visitor _____
Other _____

I HEREBY ASSUME ALL OF THE RISKS OF PARTICIPATING AND/OR VOLUNTEERING IN THIS ACTIVITY OR EVENT, including by way of example and not limitation, any risks that may arise from negligence or carelessness on the part of the persons or entities being released, from dangerous or defective equipment or property owned, maintained, or controlled by them, or because of their possible **liability** without fault.

I certify that I am physically fit, have sufficiently prepared or trained for participation in the activity or event, and have not been advised to not participate by a qualified medical professional. I certify that there are no health-related reasons or problems which preclude my participation in this activity or event.

I acknowledge that this Accident **Waiver** and **Release** of **Liability Form** will be used by the event holders, sponsors, and organizers of the activity or event in which I may participate, and that it will govern my actions and responsibilities at said activity or event.

In consideration of my application and permitting me to participate in this event, I hereby take action for myself, my executors, administrators, heirs, next of kin, successors, and assignees as follows:

(A) I WAIVE, **RELEASE**, AND DISCHARGE from any and all **liability**, including but not limited to, **liability** arising from the negligence or fault of the entities or persons released, for my death, disability, personal injury, property damage, property theft, or actions of any kind which may hereafter occur to me including my traveling to and from this event, THE FOLLOWING ENTITIES OR PERSONS:

The AggieFab Laboratory and/or The Texas Engineering Experiment Station and/or their directors, officers, employees, faculty, researchers, volunteers, representatives, and agents, the activity or event holders, activity or event sponsors, activity or event volunteers.

(B) I INDEMNIFY, HOLD HARMLESS, AND PROMISE NOT TO SUE the entities or persons mentioned in this paragraph from any and all liabilities or claims made as a result of participation in this activity or event, whether caused by the negligence of **release** or otherwise.

I acknowledge that the AggieFab Lab and their directors, officers, employees, faculty, researchers, volunteers, representatives, and agents are NOT responsible for the errors, omissions, acts, or failures to act of any party or entity conducting a specific event or activity on behalf of the AggieFab Lab.

I acknowledge that this activity or event may carry with it the potential for death, serious injury, and property loss. The risks may include, but are not limited to, those caused by being in the proximity of toxic chemicals, toxic gases, sensitive instruments and high voltage instruments. These risks are not only inherent to participants, but are also present for volunteers.

I hereby consent to receive medical treatment, which may be deemed advisable in the event of injury, accident, and/or illness during this activity or event.

I understand that at this event or related activities, I may be photographed. I agree to allow my photo, video, or film likeness to be used for any legitimate purpose by the event holders, producers, sponsors, organizers, and assigns.

The accident **waiver** and **release** of **liability** shall be construed broadly to provide a **release** and **waiver** to the maximum extent permissible under applicable law.

I CERTIFY THAT I HAVE READ THIS DOCUMENT, AND I FULLY UNDERSTAND ITS CONTENT. I AM AWARE THAT THIS IS A **RELEASE** OF **LIABILITY** AND A CONTRACT AND I SIGN IT OF MY OWN FREE WILL.

_____

Print Participant's Name

_____ _____

Signature Date

_____

Print Tour Leader's Name

5.5 Appendix 5: Equipment Training Form

Equipment Training Form

Please note the following requirements for AggieFab equipment training:

• First-time AggieFab users must take the initial area specific and cleanroom gowning training and also set up an iLab account. To receive the initial cleanroom and equipment training, the user has to contact the appropriate trainer. The tabs for the list of trainers and sheet certifying the completion of area specific training can be found on this page: https://aggiefab.tamu.edu/training/. The signed sheet must be provided to the program specialist.

• For equipment training, the user is required to read the standard operating procedure for the equipment that is available on the AggieFab website (https://aggiefab.tamu.edu/equipment/) before coming to the training session.

• During the first training session, the trainer demonstrates the proper usage of the equipment and goes through an actual run using a test sample. The trainee is encouraged to take notes and ask questions. During the second training session, the new user demonstrates the proper usage of the equipment to the trainer. The first and second training sessions must occur on different days and may be by different trainers, depending on the piece of equipment.

• If the second training session is the final training session (e.g., for less complicated pieces of equipment), then the second training session is considered the final check-off session and must be done by trainers who can provide check-off training and are generally members of AggieFab staff. Except for specific pieces of equipment, the check-off trainer must be different than the initial trainers.

• After this form is filled out by the trainee, he/she notifies the AggieFab lab manager and program specialist by emailing the form or providing a hard copy to them. The program specialist will then provide reservation permissions in iLab and building access, if needed. The lab manager makes the final decision on whether the user is authorized to operate the equipment on their own and retains the right to revoke the privilege if a cause for doing so arises.

• If the trainer fails the user during the check-off session, the user needs to practice further either with the trainer or other authorized equipment users, and requests another check-off session

☐ Check this box if you have completed initial area specific and gowning training

Equipment Name:

Trainee Name: Tranee UIN:

Training 1 Trainer: Date:

Training 2 Trainer: Date:

Checkoff Training Trainer: Date:

***TRAINEES** Please email this form to the lab manager (sandra.malhotra@tamu.edu), all trainers, and the program specialist (hprichard@tamu.edu) to obtain iLab and building access.*

5.6 Appendix 6: Chemical Disposal Procedure

AggieFab uses a variety of solid, liquid and gas phase chemicals and materials. Please consult the website for a list of chemicals provided by AggieFab and to find DS safety sheets. Gases for processing are provided by AggieFab in high pressure cylinders. Please ask a staff member for help to handle any gas cylinders. Solids used in processing are mostly in the form of sputtering targets in the RF and DC sputter tools. Ask a staff member for assistance if you have any question in the handling of these targets, or other solid materials that may need special care for safe handling.

Chemicals in liquid form will generally be used under wet benches with fans to exhaust dangerous fumes. The white polypropylene benches are designed primarily for safe handling of acids and bases, and for developing and stripping of photoresist. These benches are set up with Deionized (DI) water, aspirators, and drains that connect to the acid neutralization system for the building.

The gray metal hoods are designed primarily for safe handling of solvents. These do not have water or drains set up. Any chemicals used under these hoods must be captured in waste containers after use.

In general, any chemical that cannot be disposed of using the aspirator or pouring down the acid drains must be collected into their respective waste containers after use. For example, solvent waste must go into the solvent waste bottle, AZ 1:1 waste must go into the AZ 1:1 waste bottle, etc. When a bottle is completely empty, please rinse thoroughly with water and mark with marker on the outside that it is a waste bottle for that specific chemical, as we do reuse empty bottle for waste. Waste bottles are stored underneath the wet benches alongside the normal chemicals. Waste bottles are considered full when the top of the waste is 4 inches from the bottle's cap. Please notify staff if there is an accumulation of waste bottles or more waste bottles are needed.

Acid Bench Aspirators:

- The aspirators are a much safer way to empty acids from containers after completing wet etch or cleaning operations. Note that ONLY acids that can be disposed into the acid drain system can use the aspirators. The aspirators dilute acids with water which then flows directly into the acid drains where it is processed by the GERB acid neutralization system.
- **DO USE** the aspirators for:
    - Disposal of piranha etch – in addition, be sure to allow piranha etch to cool for a few hours before disposal down the drain
    - HCl, HF, BOE, nitric or sulfuric acids
- **DO NOT USE** the aspirators for:
    - Solvents
    - Any metal etchant mixtures, such as aluminum or chromium etch
    - Any acid that contains metals must be disposed into waste containers
    - See below for complete list

List of chemicals that **CANNOT be aspirated and must go into their respective waste containers**. For example, AZ 726 must go into the AZ 726 waste, NOT AZ 1:1 waste, etc.

- Solvents (acetone, methanol, isopropyl alcohol) can all go into a single solvent waste container
    - If performing lift off, use separate solvent bottle and label that there is Cr/Ni/Ti in the solution.
- Photoresist developers (AZ 1:1, AZ 300, AZ 726, MF 319, MIBK)
- Photoresist strippers (AZ 400T)
- Metal etchants (copper, chromium, aluminum)

Notes on chemical disposal:

- HF can be disposed of by using the aspirator next to the wet bench sink or by pouring the acid down the drain with the sink water running. AggieFab wet benches have CPVC lines that are acid compatible and connect to the building's neutralization system.
- Piranha needs to cool down sufficiently to minimize excessive reaction. This time can range from one hour for smaller amounts to several hours for larger amounts. Never leave piranha solution out overnight. The aspirators in AggieFab automatically provide 10:1 water to acid dilution for disposal. Use the aspirators if they are available, while also allowing the sink DI water to flow for further dilution. Rinse the aspirator tip by aspirating a large beaker of DI water. This also rinses the aspirator's tubes.
- Acid mixtures designed to etch metals should NOT be aspirated nor poured down the drain. These mixtures must be collected into their respective waste bottles. Other acids or bases that are used for cleaning organic contaminations or resist can generally be disposed of by using the aspirator or pouring down the drains.
- The acid neutralization system consists of three tanks that process acids: one receives the water acid mixture, one changes the pH of the acid waste via base rock, and the third test the pH to ensure its value is safe before entering the waste stream.

5.7 Appendix 7: AggieFab-Provided Chemicals

Please see the SDS page on the AggieFab website for specific safety information on each of the following chemicals.

Acids:

- Hydrofluoric (HF)
- Sulfuric (H_2SO_4)
- Hydrochloric (HCl)

Solvents:

- Isopropyl alcohol (IPA)
- Acetone
- Methanol

Developers:

- AZ 726 MIF
- AZ Developer 1:1
- Microposit MF-319
- AZ 300 MIF
- MIBK:IPA

Photoresists:

- AZ 5214 EIR
- S1818

Strippers:

- AZ 400T stripper

Etchants:

- Chromium etchant
- Copper etchant
- Aluminum etchant
- Buffered Oxide Etch (BOE, contains HF acid)

Oxidizers:

- Hydrogen peroxide (H_2O_2)

5.8 Appendix 8: List of Approved Materials

5.8.1 Solids

Name	Description	Used For
Ag	Deposition source	Electron beam evaporator, DC sputter
Al*	Deposition source	Electron beam evaporator, DC sputter
Al_2O_3	Deposition source	RF sputter
AlN	Deposition source	RF sputter
Alumel	Deposition source	Electron beam evaporator
Au	Deposition source	Electron beam evaporator
Co	Deposition source	DC sputter
Cr*	Deposition source	Electron beam evaporator, DC sputter
Cu*	Deposition source	Electron beam evaporator, DC sputter
Er	Deposition source	Electron beam evaporator, DC sputter
Fe	Deposition source	Electron beam evaporator, DC sputter
Ge	Deposition source	Electron beam evaporator, RF sputter
In	Deposition source	Electron beam evaporator
InSb	Deposition source	RF sputter
ITO	Deposition source	RF sputter
$LiTaO_3$	Deposition source	RF sputter
Mg	Deposition source	Electron beam evaporator
Mo	Deposition source	Electron beam evaporator, DC sputter
MoO_3	Deposition source	RF sputter
Nb	Deposition source	DC sputter
Ni*	Deposition source	Electron beam evaporator, DC sputter
Pd	Deposition source	DC sputter
Pt	Deposition source	Electron beam evaporator, DC sputter

Rh	Deposition source	DC sputter
Ru	Deposition source	DC sputter
Si	Deposition source	Electron beam evaporator
SiO2	Deposition source	Electron beam evaporator, RF sputter
Ta	Deposition source	Electron beam evaporator, DC sputter
TaN	Deposition source	RF sputter
Ti*	Deposition source	Electron beam evaporator, DC sputter
TiN	Deposition source	RF sputter
TiO_2	Deposition source	Electron beam evaporator
W	Deposition source	DC sputter
Ytterbium	Deposition source	Electron beam evaporator
ZnO	Deposition source	RF sputter
Zr	Deposition source	DC sputter
C (graphite)	Substrate material	PECVD, RIE
$LiNbO_3$	Substrate material	Electron beam evaporator, DC sputter, RF sputter
MACOR (ceramic)	Substrate material	Electron beam evaporator, DC sputter, RF sputter
Polyethylene terephthalate (PET)	Substrate material	RF sputter
Polystyrene (PS)	Substrate material	RF sputter

5.8.2 Chemicals

Name	Chemical Components	Type	Used For
Acetic acid	CH3COOH	Acid	
Hydrochloric acid	HCl	Acid	
Hydrofluoric acid	HF	Acid	
Nitric acid	HNO3	Acid	
Phosphoric acid	H3PO4	Acid	
Sulfuric acid	H2SO4	Acid	
AZ 300 MIF	Tetramethylammonium hydroxide - C4H13NO	Developer	Photoresist development
AZ 726 MIF	Tetramethylammonium hydroxide - C4H13NO	Developer	Photoresist development
AZ Developer 1:1	Disodium metasilicate - Na2SiO3 Trisodium phosphate - Na3PO4	Developer	Photoresist development
Microposit MF-319	Water - H2O Tetramethylammonium hydroxide - C4H13NO Polyalkylene glycol - C2nH4n+2On+1	Developer	Photoresist development
AR 600-546		EBL developer	EBL
ZED-N50		EBL developer	EBL
MIBK:IPA	Isopropyl alcohol – C3H8O Methyl isobutyl ketone – C6H12O	EBL developer	EBL
AR-P 6200.09		EBL resist	EBL
PMMA		EBL resist	EBL
ZEP520		EBL resist	EBL

AR 600-71		EBL resist stripper	EBL
ZDMAC		EBL resist stripper	EBL
Al etchant	Phosphoric acid - H3PO4 Water - H2O Acetic acid - CH3COOH Nitric acid - HNO3	Etchant (acid)	Al etching
Buffered oxide etchant	Hydrofluoric acid Ammonium fluoride - NH4F	Etchant (acid)	SiO2 etching
Cr etchant	Water - H2O Cerium (IV) ammonium nitrate - H8N8CeO18 Nitric acid - HNO3	Etchant (acid)	Cr etching
Cu etchant	Water - H2O Iron (III) chloride - FeCl3 Hydrochloric acid - HCl	Etchant (acid)	Cu etching
Fe2O3 etchant	Hydrochloric acid Ferrous chloride - FeCl2 Ferric chloride - FeCl3	Etchant (acid)	Fe2O3 etching
Chlorobenzene	C6H5Cl	Flammable liquid	Cleaning chemical
Trichloroethylene (TCE)		Liquid chemical, degreaser	degreaser
AZ 5214	2-Methoxy-1-methylethyl acetate Diazonaphthoquinonesulfonic esters 2-Methoxypropyl acetate-1	Photoresist	
Microposit S1818	Propylene glycol monomethyl ether acetate Mixed cresol novolak resin Diazo Photoactive Compound Fluorinated Surfactant Cresol	Photoresist	
SU-8		Photoresist	
AZ 400T stripper	N-methly-2-pyrrolidone - C5H9NO Propane-1,2-diol - C3H8O2 Tetramethylammonium hydroxide - C4H13NO	Photoresist stripper	Photoresist stripping
Acetone	C3H6O	Solvent	

Isopropyl alcohol	C3H8O	Solvent	
Methanol	CH4O	Solvent	
Tetramethyl ammonium hydroxide (TMAH) - 25% by weight	C4H13NO	Solvent	Etching of Si, resist development/removal
Hydrogen peroxide	H2O2	Oxidizer	