Tufts UNIVERSITY | School of Engineering

Micro- & Nano-Fabrication Facility

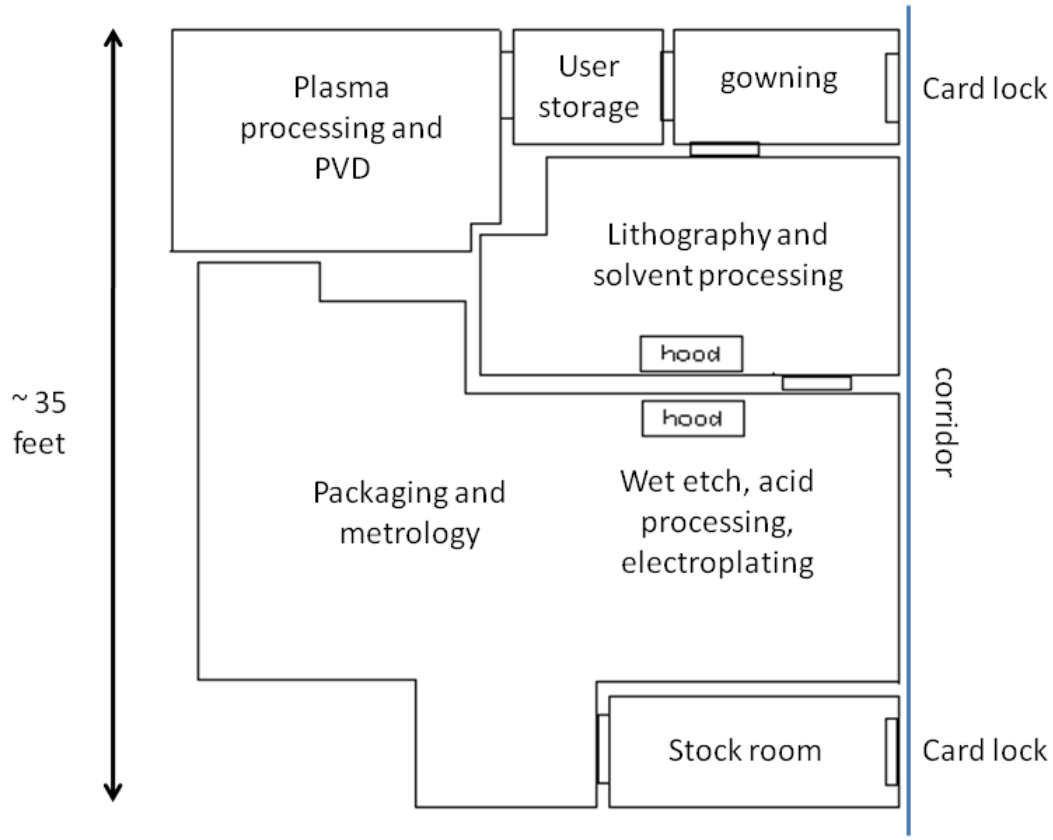
User Guide

Revised: September 24, 2018

Priorities:

1. User safety. Major danger is chemical hazards. Secondary danger is fire.
2. Lab usability. Tools and facilities should be kept in good working order. This is a shared facility.
3. Research & education.

Lab Layout



The lab is a Class 1000 cleanroom and requires cleanroom garb to enter. There are two external entrances to the lab, both on Tufts cardlock. Your entrance to the lab will be logged when you enter. You should be entering the main part of the lab **only** through the gowning room.

The stock room at the bottom right of the drawing should be entered ONLY from the corridor, and contains extra stock – waste bottles, glassware, gloves, Petri dishes, microscope slides, razor

blades, swabs, pipettes, cleanroom wipes, cleanroom gowns, etc. You may get anything from the stockroom that is needed to resupply the cleanroom. You should never enter the stock room from the inside of the lab in cleanroom gear, unless you are using it as an emergency exit.

The different rooms in the cleanroom are used for different purposes, as shown in the drawing. Of particular importance are the two chemistry hoods. One should be used for lithography and solvent processing, the other for all wet etching, acid processing, and electroplating activities.

Controlled Environment Apparel

Cleanroom suits are to protect the cleanroom from particle contamination from your body and clothing. Gowning procedure:

1. Put on shoe covers in the hallway.
2. Step on the tacky mat on the way in.
3. Put on your hat and gown.
4. Sit on the bench and put on the overboots. Only step on the clean side of the bench with the boots.

Keep your gown until it is ripped or dirty. You can claim a hangar on the rack in the gowing room. Keep your overboots as well… tie them to the hangar or something. Throw away the cap when you leave. If the shoe covers are still serviceable, put them in the top bin. If they are ripped or dirty, throw them away.

Controlled Environment Rules

No regular paper, notebooks, books, or cardboard is allowed in the cleanroom. Also no cloth, wood, or other materials which emit particles. You will need a cleanroom notebook and cleanroom paper to copy/print on to. These can be purchased from Fisher Scientific, McMaster Carr, and elsewhere. Any controlled environment paper/notebook which meets Class 1000 standards is fine.

Mobile phones, laptops, and other hard plastic or metal objects can be brought into the lab. Please wipe them down with isopropanol to remove dust on the way in. Please keep in mind that your gloves may have chemicals on them – if you touch a laptop keyboard or cell phone you may transfer chemicals to those surfaces which you then touch again with no gloves after leaving the cleanroom. If you are going to use a laptop or cell phone in the cleanroom, change gloves just before using it.

Ideally, wafers should not go in and out of the fab. You should open your box of new wafers in the fab and once they come out of the fab they should stay out. If you need to bring a wafer or chip into the packaging area and then back into the main cleanroom it's OK but try to minimize the amount of time the wafer is in the open air. Give the wafer a rinse with isopropanol when you bring it back in. The wafers go directly into the tools and glassware and will contaminate them with particles if they are dusty.

Personal Protective Equipment (PPE)

You must wear the following at all times in the cleanroom:

1. Nitrile gloves.
2. Safety glasses.

These items are available in the gowning area.

In addition, when working in the chemical hood you must wear:
1. Trionic over-gloves.

Finally, when working in the chemical hood with acids or bases, you must also wear:
1. Apron
2. Faceshield

The cleanroom gown will not protect you from chemicals.

Chemical Safety

NFPA Diamond Hazard ID System: The higher the number, the more dangerous. Range:0-4.

Red: Flammability. 4=easily vaporizes and ignites easily. 3=ignites easily
Yellow: Reactivity. 4=can explode by itself at room temperature. 3=can explode with some initiating event (heating, mixing with water or something else)
Blue: Health. 4=can cause death or serious injury by short exposure 3=can cause injury by short exposure

Special Symbols

W	Material shows unusual reactivity with water (i.e. don't put water on it).
OX	Material possesses oxidizing properties.
ACID	Material is an acid.
ALK	Material is a base (alkaline).
COR	Material is corrosive.
☢	Material is radioactive.

No radioactive substances are allowed in the lab.

No biohazards are allowed in the lab.

No new chemical is allowed in the fab without Prof. White's approval. You must supply a standard operating procedure for how the chemical will be used (template is on the website). You must also supply an MSDS, information on chemical compatibility, and instructions for waste disposal.

When you first work with a chemical you are not familiar with:

1. Read the MSDS (in the binder in the gowning room or online). Identify major hazards. (Is it flammable? Is it highly toxic? Does it react violently with anything else in the lab?)

2. You also need to determine what materials it is compatible with so you know what kind of container to use, and whether it will react with your tweezers, etc.

3. You need to know how to dispose of the chemical. (See SOP for your process and the MSDS)

General rules:

1. Only work with chemicals in the fume hood. NEVER PUT YOUR HEAD INSIDE THE HOOD.
2. Wear personal protective equipment as described above.
3. Do not mix organic solvents with acids or bases. Do not mix acids with bases. Do not mix bases with acids.
4. When diluting acid or base with deionized water, always pour the water first and pour the acid into the water. Mixing strong acids with water releases large amounts of thermal energy. Adding water to acid will, initially, create an extremely concentrated solution which releases so much heat the solution may boil violently, splashing concentrated acid out of the container. Adding acid to water forms a dilute solution and releases small amounts of heat, not enough to vaporize and spatter. So **Always Add Acid** to water, never the reverse.
5. Almost nothing reacts with PTFE (Teflon).
6. Many solvents attack some plastics but not others. You need to look up chemical compatibility for any unfamiliar chemical!
7. Acids and bases may react violently with some plastics and metals, and sometimes also attack glass. You need to look up chemical compatibility for any unfamiliar chemical!
8. Never add concentrated nitric to the organic waste bottle. It creates a slow exothermic reaction and results in an explosion in the lab.
9. Concentrated sulfuric acid can cause very serious damage upon contact as not only does it hydrolyze proteins and lipids leading to chemical burn, but also dehydrates carbohydrates posing secondary thermal burn
10. You may leave chemicals in the hood for up to a week, but you must cover them and label them with the material name, your name, and the date.

Safety fixtures:

1. There is a safety shower in the lab. If you spill a hazardous chemical on yourself, get under the shower, pull the handle (with your clothes still on), and then get the clothes off. The goal is to dilute the chemical quickly. Call for help.
2. There is a safety eyewash in the lab. If you get anything in your eye, flush it with water for 15 minutes. I'm serious! 15 minutes! You don't want to damage your eyes.

Reacting to a spill:

1. A spill is a minor spill if: The spill occurs inside the hood and is well contained, the material is not acutely hazardous, and there is no risk of fire. Clean it up yourself.
2. A spill is a major spill if: The spill occurs outside the hood and is not contained, the material is acutely hazardous, or there is a risk of fire. Turn off any hotplates. Get everyone out of the lab and call Tufts emergency services at x6-6911.

Hydrofluoric acid (HF): Do not work with HF in the lab by yourself.

1. Exposure of a significant amount of HF to the skin can kill.
2. Minor exposure of the skin to HF can result in chronic health problems.
3. HF does not cause a surface burn like other acids… it penetrates into the body and attacks bone, as well as moving around the body in the blood.
4. Wear all the personal protective equipment: safety goggles, faceshield, nitrile gloves, trionic overgloves, apron. Be careful when working with HF! Be deliberate and gentle.
5. If you get a small amount of HF on your skin: rinse the area for 5 minutes (sink) then apply calcium gluconate, then call Tufts health services.
6. Calcium gluconate is stored in a tube on the metal shelves by the telephone.
7. If you get HF in your eyes: Rinse your eyes in the eyewash for 15 minutes. DO NOT put calcium gluconate in your eyes. Call Tufts EMS x6-6911.
8. If you get splash a large amount of HF on yourself, get under the shower, strip in the shower, and call Tufts EMS x6-6911.

Hydrogen Peroxide (H2O2), (in particular applies to Piranha):

1. Piranha mixture is exothermic. Before disposing of the liquid waste, you must allow it to cool. Otherwise, the temperature gradient may break the glass bottles.
2. H2O2 waste is an explosion hazard, all H2O2 waste bottles must utilize a vented cap. Ensure such caps are available *before* proceeding.
3. H2O2 and solvent mixtures can produce *very energetic chemical reactions* (read: explosions). Ensure your work area is entirely free from solvents before proceeding. Make sure you are working with a lab partner.

Solid Waste Disposal

There are four types of trash cans:

1. Solvent and photoresist waste. For organic-contaminated solids.
2. Acid and base waste. For acid/base contaminated solids.
3. General trash: For uncontaminated solids (paper, gloves and caps, etc.)
4. Sharps trash: For anything sharp… broken silicon or glass, razor blades, needles, etc.

Empty Chemical Bottles

Empty chemical bottles should be treated as hazardous waste bottles. When you empty a bottle, simply put a hazardous waste tag on it, write the name of the chemical that was in the bottle on the tag, and put it in the hazardous waste accumulation area under the hood.

This chemical bottle now becomes a waste bottle for the chemical that it originally contained and anything that is compatible with this chemical.

Liquid Waste Disposal

Active waste containers are stored under the hood. Additional empty glass and high density polyethylene (HDPE) waste bottles are available on the shelving unit and in the stock area. There are funnels for pouring into the bottles under the hood. Make sure the funnel material is compatible with your waste type! There are metal and polypropylene funnels. Pour inside the hood and then put them back under the hood.

Each waste container must be labeled with name of chemicals inside (note – not the trade name, but the official chemical name) and the associated hazard. On each fume hood you will find a sign that identifies the chemical trade name, the corresponding chemical name and the associated hazard. If you start a new waste container, make sure it is compatible with the chemical, and be sure to create a new tag.

Periodically chemical waste technicians will sweep through the lab and remove full containers of chemical waste, both liquid and solid. If solid waste containers, or the accumulation area under the hood, are filled please notify Prof. White or Dr. Vlahakis and we will schedule a waste pickup.

There are a number of different types of waste in the lab. In the front of both the MSDS and SOP binder, and on the website, there is a chemical list which describes how to dispose of every chemical in the lab. Refer to this list to determine what type of bottle to use for your waste, and what other types of waste your waste can be mixed with.

Dilute water waste:
A 5 gallon high density polyethylene waste container is available on top of the chemical cabinets for dilute acid/base water waste. This is rinse water used to rinse acid/base glassware the second and third times, and contains very dilute amounts of waste. It should never be used with any organic solvent waste, no matter how dilute.

Tool Use and Training

OAI Mask Aligner, PDS2010 Parylene Coater, NSC-3000 DC Sputter Tool, MA1006 Dicing Saw, March CS1701 Etcher, Marpet Ball Bonder: You must pass a formal checkout procedure with Prof. White to use this tool. Arrange with qualified users to observe when they use the tool. Have other qualified users help you use the tool twice. Once you are comfortable, contact Prof. White to be tested. If you pass the test, you will be allowed to use the tool by yourself.

Chemical hoods: You may use the chemical hoods after doing the online training and going through safety training. Whenever you are performing a procedure in the hood, you must read the SOP beforehand. Work with another user the first time you do a new procedure to make sure you are clear on how to do it. Be careful! There are dangerous chemical being used here!! Any new process or chemical that has not previously been conducted in the fab must have an SOP written for it and approved by Prof. White. If you are at all unclear about anything, ask other users or faculty and make sure you are clear.

Spinners, Tegal Plasmod, Dektak 6M, Zygo, Nanocalc, Thermolyne Oven, Four Point Probe:
Set up to observe and work with a qualified user or faculty member. Once you are comfortable, you are allowed to use it by yourself. There is no formal checkout procedure. The SOP is always available online or in the binder.

Microscopes, hotplates, ovens: No training required.

Shared Hand Tools and Glassware

Anything on the various shelves throughout the lab is for general use, unless the shelf is labeled with a user's name. Please clean items before returning to the shelves.

Glass- and plasticware must be rinsed two or three times with water before returning to the shelves. If it is wet, put it on a fab wipe on the shelves so it doesn't drip down on things below.

Glass- and plasticware should be labeled for a specific purpose such as "HF" or "acetone" or "solvents". If there is not already a container for your purpose, make a new one, and put tape and a label on it.

Deionized Water

A central deionized water system provides DI water (approximately 17.5 MΩ-cm) to two DI water spigots located in the two chemistry rooms. There is a resistivity meter on the wall next to one spigot which can be used to monitor the quality of the DI water. Typical resistivity is in 17 MΩ-cm range

Storage Space

Anything that you don't want other people to mess with can be stored on your shelf in the storage area. Respect other people's tools… don't borrow someone else's tweezers; perhaps they need them to stay very clean and they will be mad when you get SU-8 on them and it ruins their device.

Email List

There is a lab email list that you will be added to when you are granted lab access: microfab-users@elist.tufts.edu

You can email the list with questions or concerns of any kind related to the lab.

Vendors

Suggestions for vendors (there are tons more… just to get you started):

Cleanroom notebooks/paper:	Fisher Scientific or McMaster Carr.
Wafer tweezers:	Tedpella (try prod #5587) or Fisher 19-035-517
Wafers:	Nova Electronic Materials (novawafers.com), universitywafer.com
Chemicals:	Fisher Scientific, Doe & Ingalls, Inc. (Medford, MA) http://doeingallsma.com
Photoresists:	MicroChem Corporation; I suggest SPR-220 series as standard positive resists

Transparency masks:	Advance Reproductions Corporation (advancerepro.com) Note: This is a local company (Andover, MA)
Glass masks:	Advance Reproductions Corporation (advancerepro.com) 5” x 5” x 0.09” chrome on soda lime. Note: This is a local company (Andover, MA)
Glass mask blanks: (photoresist coated)	Telic (www.telicco.com) 5” x 5” x0.09” Cr on Soda lime glass, coated with AZ1518 photoresist

Final Thoughts

This guide will cover the vast majority of situations that arise in the microfab, but we cannot foresee all possibilities. If you encounter an issue beyond the scope of the guide your primary consideration should be safety – both your own and that of other lab users.