

TOP Center Clean Room User Manual

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INTRODUCTION

The NTHU TOP Center micro fabrication Facility, located in 光電實驗館 on the National Tsinghua University Campus, is an open-access facility for micro and nano-scale research, development, prototyping, and fundamental science. The lab represents more than \$10 million in facilities and equipment, and is currently partially supported by the Taiwan Ministry of Science and Technology (MOST). The TOP Center microfabrication facility offers a full range of semiconductor processing and packaging capabilities, including photolithography, wet etch, sputter deposition, evaporation, dicing and inspection. We strive to enable rapid advancements in photonic science, engineering and technology.

GENERAL INFORMATION

WEBSITE AND CONTACTS

Up-to-date contacts, news, and information about the TOP Center Microfabrication lab can be found at our website,

<https://>

USING THE FACILITY

Users are classified as either NTHU (internal students, faculty, staff, or business unit with a NTHU budget number) or external (non-NTHU). External users are further categorized as academic (other academic institutions, governments and agencies, and certified non-profit organizations) or industrial (all other for-profit organizations). As a user facility, the most common paradigm is for individuals to process their devices in person (onsite users). An alternative approach is contract facility staff to perform limited scope fabrication processes (remote users).

ONSITE USERS

While working at the TOP Center Microfabrication facility, you will learn a variety of processes and gain valuable skills. After a lab orientation and wet bench training, you will sign up for equipment training as needed. We advise finding a mentor or consulting with staff to ensure proper cleanroom technique, especially if you plan to repeat or expand upon an established process.

REMOTE USERS

WNF staff engineers are available to conduct limited-scope process work on a best effort, time and materials basis for remote users. Due to the experimental nature of most contract processes, we cannot provide product guarantees, but will work closely with clients to determine project feasibility, to provide cost estimates, and attempt to obtain mutually satisfactory results. Remote users will be assessed a fee for sample shipping.

BECOMING A USER

Before becoming a user, we suggest scheduling a meeting with staff to discuss your project and, optionally, to see the facility. Next, you will need to complete the registration process on the new user site at:

BILLING

CONSULTING

INTELLECTUAL PROPERTY AND SECURITY

CLEANROOM POLICIES AND PROCEDURES

CODE OF CONDUCT

Assume responsibility for the lab. Always follow safety, equipment, and cleanliness protocols, even if your work is not sensitive to contamination or particulates. Never leave a mess; if you find one, either clean it, ask the responsible parties to clean it, or notify staff. Report equipment problems, and notify staff and other users if you have made a mistake or may have caused contamination. Share space and respect equipment reservations. Ask questions if you are unsure. The lab operates effectively when everyone is cordial, follows instructions, and communicates

AUTHORIZATION TO USE THE CLEAN ROOM

Before authorization is granted for clean room access and equipment use, competency in operating safely in the lab and equipment must be determined. Individuals must demonstrate they can perform the appropriate safety protocol and operating equipment they wish to use according to the standards set up by the clean room manager or staff in charge of the equipment before they are allowed to enter the clean room and use the appropriate equipment that they have been certified to use.

PERSONAL EFFECTS STORAGE

While you are working in the labs or cleanroom, store all personal items, such as coats, knapsacks, bicycle helmets, books, etc., in the metal cabinets in the front entrance (bottom two rows) or outside of the clean room hallway in front of the cleanroom entry door. Do not bring any of these items into the gowning room or cleanroom. This is a short-term storage; items left for prolonged periods may be disposed or reclaimed.

CLEANROOM ITEM/ACTIVITY RESTRICTIONS

People and the items they bring into the cleanroom are primary sources of particulate contamination. In addition to the table above that applies to all TOP center clean room spaces, the table below lists items that can and cannot be brought into the cleanroom. Minimize contamination by only bringing items necessary for your research into the cleanroom.

Partial List of Prohibited Items/Activities Allowed Items/Activities

Cardboard, fiberboard, wooden containers Plastic items, plastic boxes, plastic containers
 Paper, paper notebooks, books, magazines, etc. Cleanroom paper, cleanroom notebooks
 Pencils, erasers Pens Over-the-ear headphones Ear bud headphones (keep at low volume)

Hats, coats, scarves, bags, backpacks, etc. Over-the-ear if fully under hood (at low volume)
Makeup, cosmetics Laptops, e-readers, cell phones, running jogging.

GOWNING PROCEDURES



Step 1: Cover the hair properly with **bouffant cap or hair mesh**, for long hair first tie the hair and then cover the with the cap.

Step 2: Put on **the clean room face mask**, any mask already put must be removed and a new mask must be used.

Step 3: Pick up the available **clean room bunny suit** according to size from cabinets at the second last row of the metal cabinets (cabinets without names). Put your **legs first in the suit and then your hands without touching suit to the ground**. Zip the suit, put the hood on your head over the hair mesh and put the strap on available at neck at last.

Step 4: Pick up a pair of **clean room boots** according to your size available in the cabinets at last row of same metal cabinets. After putting your feet in the shoes, before zipping **make sure you cover your suit near ankle region inside the shoes** and then zip it.

Step 5: Pick up **the clean room goggles** from the box, adjust or loosen the strap accordingly and then wear the goggles such that strap is over the hood at back. **People with spectacles can choose not to wear the goggles**. Make sure that every part of face is properly covered with mask and goggles.

Step 6: The **purple Nitrile Gloves** must be the last thing to wear after making sure that everything is put on properly.

Before entering the chamber make sure that every inch of your body is covered and dirt and dusts

- Using an IPA squirt bottle, moisten a cleanroom wipe and wipe down all the items you bring into the cleanroom.
- Once inside the cleanroom, do not open or unzip your cleanroom suit. If you need to access something within your suit (e.g. cell phone), go to the gown room and do so.

CLEANROOM PROTOCOL

All users must help maintain the integrity, usability, and effectiveness of the cleanroom. Even if your project is not sensitive to particulates or other contamination, you must follow all cleanroom protocols at all times.

- If your gloves are torn, soiled, or otherwise contaminated, immediately remove the outer pair and put on new gloves.
- Never touch doorknobs, telephones, equipment controls, microscopes or other common objects with contaminated gloves. Cross contamination can permanently damage equipment and expose other users to chemical hazards.
- Tacky mats are placed throughout the lab to reduce airborne particulates. Do not step over or bypass the tacky mats.
- Do not leave items strewn about the lab. Use your assigned dry box storage space. Items left in the lab will be moved to the lab lost-and-found, in the east gray space. After one week, unclaimed items will be discarded or reclaimed.
- If you need something from under your suit, do not unzip your suit in the cleanroom. Move to a gray area (gowning room or maintenance/storage chase) to open your suit. If you intend to use the retrieved item in the cleanroom space, it must be wiped with IPA.
- Do not sit or lean on equipment or tables.
- Do not shake hands in the cleanroom.
- Use all materials (e.g. wipes and chemicals) sparingly to keep costs down.

WAFER HANDLING

CASSETTES

Whenever possible use cassettes to carry and process your wafers, except in cases where using a cassette would result in excessive and unnecessary chemical usage. Although you can orient wafers in your cassette however you please, they are generally positioned starting from the H-bar (horizontal bar) with the polished surface facing away from the H-bar. Cassette-to-cassette transfers are the 12 easiest method to transfer a large number of wafers. First, set the filled cassette on a flat surface, then flip an empty receiving cassette upside down and mate the two cassettes using the dimples and holes. Grab both cassettes, compress them together, and then slowly tilt both until the wafers roll from the donor cassette to the receiving cassette.

TWEEZERS

Only handle wafers with wafer tweezers. Only touch tweezer handles; do not touch the shovel or pincer (gripping end). Ensure your tweezers are compatible with the chemicals your processing requires. Use care to avoid gouging equipment (e.g. hotplates). Pick up wafers from the major flat whenever possible. When carrying wafers, it is advisable to hold your other hand under the wafer in case you drop it. Clean your tweezers regularly.

GLOVES

Do not touch the front or back surfaces of your wafers. Your gloves are always contaminated to some extent. Brand new gloves can have plasticizer residues, or you may have accidentally touched something dirty or dusty. Unless you have a very specific reason, you should never touch your wafers with your hands. However, for some processes, such transferring wafers with freshly spun thick photoresist (e.g. SU-8 2100) to a hotplate, it may be appropriate to carefully transfer your wafer by lifting it gently from the edges with a doubled gloved hand (never pinch with your thumb and index finger). Another example would be to avoid transferring tweezer marks to a hard mask if you plan to do anisotropic silicon wet etching. Again, change your outer gloves immediately if they become contaminated for any reason.

WORKING WITH CHEMICALS

You are responsible for understanding this laboratory safety manual and abiding by its rules. Additionally, there are several EH&S online safety courses you must require to complete to become a lab user.

UNDERSTANDING HAZARDS

Do not use or handle any chemical until you read and understand its label and material safety datasheet (MSDS). Understand the hazards, handling, storage, disposal, and emergency procedures for every chemical you use. SDSs are located at the gowning room. You also need to know evacuation routes and locations of eyewashes, and shower stations.

GENERAL SAFE PRACTICES

- Do not taste, touch, or smell any chemicals.
- Do not mix, heat, dispose, or otherwise use chemicals in an unauthorized manner.
- Work with chemicals in an exhausted fume hood or wet bench.
- Use chemicals only in wet benches where they are approved.
- Never mix acids and solvents.
- Never dispose of solvents down water drains or water down solvent drains.
- Change your gloves if they might be contaminated.
- Label your chemicals.
- Do not place or store chemicals above the level of the wet bench surface.
- Never remove chemicals from the lab without permission.
- Use chemicals and cleanroom wipes sparingly.
- Do not interrupt users working with chemicals.
- If you are unsure of handling or safety procedures, ask questions.

BUDDY SYSTEM

Most chemicals used for cleaning and etching wafers are very dangerous, so it is required that another authorized cleanroom user accompanies you while you are working at the wet benches. A buddy is required for all wet processing performed in wet benches on the north side of the photolithography room. All dry processes are permitted without a buddy; however, it is recommended that you coordinate lab activities to ensure that at least one other person is in the vicinity. You may not assume that someone is your buddy if they happen to be in the lab. You must explicitly notify them that you need a buddy, and they must accept that responsibility. Your buddy may not leave until chemical operations are completed and you have cleaned up.

CHEMICAL CLASSES AND STORAGE

ACIDS

Acids are substances that donate protons when dissolved in water. Acids are used for etching metal and cleaning wafers, are generally corrosive, and can be toxic or water reactive (e.g. sulfuric acid). Acids are stored in the **blue corrosives cabinets on the northeast side of the class 1000 room.**

BASES

Bases accept protons, and can increase the hydroxide ion concentration when dissolved in water. Many photoresist developers are dilute bases, and some concentrated bases can be used to etch silicon. Bases are stored **in the upper gray cabinets on the northeast end of the class 100 room.**

OXIDIZERS

Oxidizers are agents that are easily reduced, and generally supply oxygen to chemical reactions. Examples in the lab include hydrogen peroxide and nitric acid. Oxidizers can react violently with organic chemicals.

SOLVENTS

Although the term “solvent” refers to any liquid used to dissolve another material, in a cleanroom setting “solvents” are typically organic liquids that are flammable or combustible. We use acetone, isopropyl alcohol, methanol, n-methyl pyrrolidone, dimethyl sulfoxide, and a variety of others. Photoresists are usually photoactive polymers suspended in organic solvents such as propylene glycol monomethyl ether acetate (PGMEA) or cyclohexanone. Solvents and photoresists are stored in the yellow flammables cabinets on the east wall of the photolithography room. Photoresist strippers and solvent waste containers are **kept in the blue cabinet next to the southeast emergency exit of the photolithography room.**

NEW MATERIALS REQUESTS

Before bringing a new chemical into the cleanroom, you must submit a New Materials Request Form, an MSDS, which will be sent to the lab manager and the lab safety manager for approval. We do not permit long-term storage of any personal chemicals in the facility or wet benches without explicit permission.

WET BENCH TYPES

The photolithography room has plastic (chlorinated polyvinylchloride) wet benches. Organic solvents such as acetone, isopropanol, and SU-8 developer are not allowed on the plastic benches because they will dissolve the working surfaces. Acids and bases are not allowed on metal benches. You are responsible for understanding the specific requirements and chemical restrictions for each bench.

AVOIDING FUMES

Fume hoods are designed to limit your exposure to chemical fumes and are equipped with pressure gauges and sash height sensors to ensure safety and proper operation. Although the benches are designed to turn off during exhaust outages, check the pressure sensors to make sure the pressure is within the acceptable limit. Many fumes in the lab are toxic, corrosive, or carcinogenic, so it is important to only work under the sash for very brief periods of time and only when absolutely necessary.

PERSONAL PROTECTIVE EQUIPMENT

You are required to use additional personal protective equipment (PPE) when working in the wet benches on the north side of the photolithography room and when transferring chemicals to and from the corrosives cabinet.

DONNING PPE

PPE consists of three items that should be donned in the following order: a chemical apron, a face shield, and chemical gloves. Check all items for damage before use. Look for cracks or pinholes in gloves, tears or holes in aprons, and scratches or cracks in face shields. If any gear is damaged (e.g. ripped apron or gloves), discard it and use another item. Rinse damaged items with DI and dry before disposing. Use care when putting on aprons to avoid ripping the seams, and make sure the apron sleeves are fully tucked under the chemical gloves.

WEARING PPE

Do not touch anything unnecessarily with the chemical gloves and treat them as though they were contaminated. For example, do not touch face shields, sashes, controllers, or any other equipment with the chemical gloves, and do not leave the photolithography room while wearing chemical gloves. It is acceptable to leave your chemical gloves on the edge of a wet bench while you work elsewhere. The apron must fully cover your shoulders at all times (i.e. make sure it is tied around the neck and do not let it slip off while you work). Wearing PPE is not an excuse to act in an unsafe manner. Do not ever put your hands or fingers into a chemical bath, and always avoid splashing or spilling chemicals. Also, PPE provided by the TOP center

clean room is only for temporary protection. It will not protect you from a spill, splash, or mist for a prolonged period of time.

DOFFING PPE

Rinse and dry the chemical gloves, remove them and hang them up. Hang face shields and avoid scratching the plastic. Lastly, remove the apron and be careful to avoid ripping it. If condensation has accumulated in the apron, use a wipe to dry the inside. Do not leave the apron inside out.

LABELING

Prior to filling, all chemical containers must be properly labeled even if you do not intend to walk away. You must include your name, the chemical name, and the date. If you plan to leave chemicals out after leaving the room, a phone number or email and an expected time of disposal must also be provided. Water must be labeled. If the chemical is not regularly used in the cleanroom (e.g. it was brought in after approval from the lab staff), list all hazards.

POURING CHEMICALS

Assume that all chemical bottles are contaminated. Use a bottle carrier when transferring chemicals to and from storage locations. Immediately before pouring, always recheck the chemical label and make sure the chemical container you intend to use is set flat on the wet bench surface. Do not try to pour small volumes from gallon jugs; instead, transfer chemicals from gallon jugs to graduated cylinders or beakers, and then pour again from this secondary container. Use good judgment and do not overfill containers (i.e. do not fill them so close to the top that moving the container or disposing the chemical is unsafe). Never return poured chemicals to their original container. Use containers that are compatible you're your chemicals. For example, some chemicals or solutions, such as piranha (a mixture of sulfuric acid and hydrogen peroxide), cannot be stored in closed containers even for brief periods of time because it outgases and could cause an explosion. Also, hydrofluoric acid cannot be used with glassware because it will dissolve the container.

CHEMICAL BOTTLE CLEAN-UP

Use chemicals in partially used bottles before opening new bottles. Properly clean empty chemical bottles before disposal. Leave empty solvent bottles open in the hood. After the solvent residue has evaporated, fill the bottle half full with DI water and dump down a water drain. Repeat this process three times. Acid and base bottles must also be rinsed by filling the bottle half full with DI water, emptying the bottle into a water drain, and repeating at least three

times. After rinsing, dry the outside of the bottle with wipes, use a black marker to cross out the label, and then write "Rinsed 3x" in at least two different locations on the bottle. Set the empty, rinsed, dry, and labeled bottle in the bottom shelf of the blue photoresist stripper cabinet.

DISPOSING SOLVENTS

To dispose of used solvent, empty it into a solvent drain or into an appropriate waste container. A list of solvents allowed into the solvent drains is posted on the hood. Clean the chemical container with an acetone soaked wipe, and then wipe thoroughly with isopropanol (IPA). Remove the label with acetone or IPA (do not bring a solvent squirt bottle into a plastic bench), rinse with DI at any of the plastic benches, and return the container to the drying rack.

DISPOSING ACIDS AND BASES

There are plastic waste bottles clearly labeled for each chemical waste. Take the chemical containers to the south side of the room.

HANDLING SMALL SPILLS

Attempt only to clean small spills for which your training and experience are appropriate, provided you can do so safely without taking unnecessary risks. Large spills or spills outside of wet benches should be treated as emergencies. Refer to the Chemical Emergencies section of this manual. Clean small solvent spills with lint-free wipes and dispose them in the red solvent waste can. Then use acetone and IPA with wipes to clean the metal surface. Clean acid or base spills in plastic benches by thoroughly rinsing the working surface with DI from a spray gun. Use care to avoid getting water in staff-maintained baths. Do not wipe up chemicals directly with cleanroom wipes without first rinsing and diluting the spill thoroughly. This is of particular concern with highly oxidizing agents (e.g. hydrogen peroxide or nitric acid), because of the potential fire hazard. After rinsing the surface, use a plastic scraper to move the water into the cracks between bench panels or into the sink (not into baths). Once you are sure that there is only water left on the surface, dry the remaining drops of water with a wipe to leave a clean, dry surface. Wipes are expensive; use sparingly.

HOTPLATE SAFETY

Hotplates are used extensively for baking photoresist and occasionally for heating solutions. Do not touch hotplate surfaces. Use extreme care when hotplates are used in proximity to flammable solvents or other liquids. Do not spill on hotplates or spray water on hotplates, and do not heat high vapor pressure solvents. For example, do not heat up acetone or isopropanol. It is acceptable to remove hotplates from a wet bench if you need more room or if you feel more comfortable working without one in the hood. If you need to heat an organic solvent or

material in a bottle (e.g. SU-8), heat the container in a water bath, not directly on a hotplate.

LEAVING WORKSPACES

After using a bench or other workspace, clean up all chemicals, chemical containers, wipes, and other materials (samples, tape, markers, notes, personal effects, etc.). Always leave wet bench surfaces clean and dry within comfortable arms reach, and as organized as possible. It is not necessary to clean out the cascade rinse tanks or the very back of the bench tops.

EMERGENCY PROCEDURES

If you find yourself involved in a major emergency, do not be shy or embarrassed about calling for help or pulling the fire alarm. If possible, when emergency personnel arrive, approach them, tell them that you were involved with the incident, and be ready to explain what happened.

EMERGENCY COMMUNICATIONS

TELEPHONES

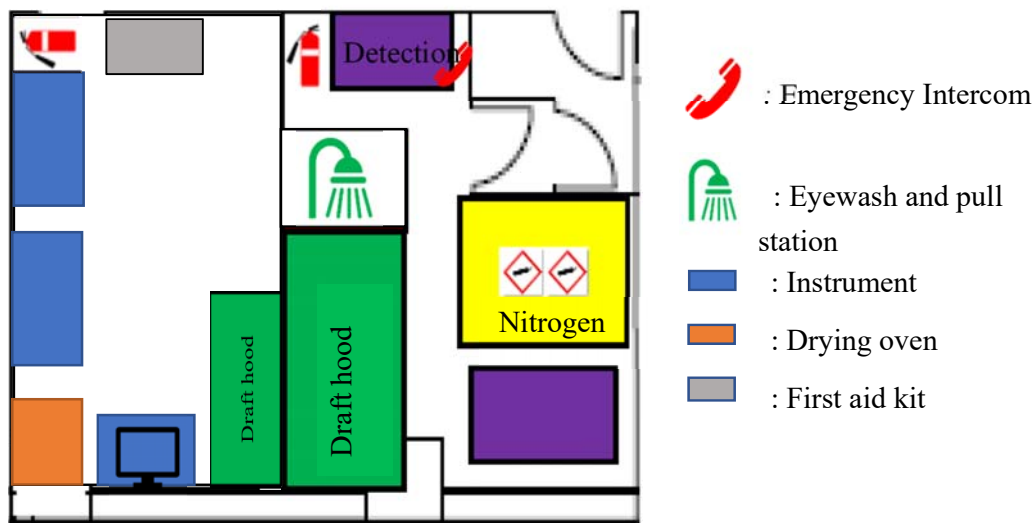
Use a cell phone or the campus telephone system to report emergencies. In case of a system failure or a power failure, campus phones will not function. Here are a list of numbers to contact in case of emergency:

Hsinchu Fire and Police department: 03-579-0102 or 119

EVACUATION PLAN

The floor plans below identify exits and exit routes for the building. Occupants should go to the nearest exit during and evacuation. If access to the nearest exit is obstructed, an alternate exit should be taken.

Clean Room Floor Plan



CHEMICAL EMERGENCIES

SPILL RESPONSE

In order to become an onsite user, you are required to complete the TOP center Managing Laboratory Chemicals online training course. This training outlines chemical handling and emergency procedures. If you cause or encounter a chemical spill, respond accordingly based on the following scenarios.

- Risk of fire or spills that could spread out of the room: Pull the nearest fire alarm. This alerts the local fire and police departments that there is an emergency at your location and sounds the alarm in the building for everyone to evacuate. Leave the building, helping others as necessary. Then, if possible, call 119 tell them what happened. Stay on the scene to help personnel respond to the emergency. Do not fight any fires yourself.
- No risk of fire, spill and vapor contained in the room, but someone is injured or exposed: Call 119 only. If someone has been exposed to a chemical, begin decontamination and/or first aid as soon as possible. Evacuate the room and wait for emergency personnel to arrive.
- Everyone is safe, but there is a large chemical spill: Contact the lab staff or Call 119 after normal business hours and ask for EH&S chemical spill advice. Staff will advise you on how to clean up your spill. Only attempt to clean small spills for which your training and experience are appropriate. Contact staff for large spills (>100 mL) or spills outside of a wet bench. Do not clean spills that occur outside of the fume hood that may require specialized respiratory protection (e.g. large acid or solvent spills, including any HF spills).

CHEMICAL EXPOSURES

Working with chemicals is dangerous. Even common mistakes like dropping a container or leaving a reaction unattended for "just a minute" can have serious consequences when chemicals are involved. Work carefully and deliberately; keep in mind what to do if things go wrong. Read the MSDS for all chemicals you plan to use to ensure you are aware of hazards and emergency procedures. Avoid exposures by following the rules below:

- Don't work with chemicals when you're too tired to think clearly.
- Keep your workspaces clean and organized.
- Wear personal protective equipment If you are exposed to a chemical (other than hydrofluoric acid, discussed in the next section), do the following:
 - Stay calm. Move out of the contaminated area.
 - Get the chemical off. Fast dilution is key. If the chemical is on skin or soaking through your clothing, go to the safety shower. Pull the handle on the safety shower, and do not worry about.

HAZMAT EMERGENCIES

Pull one of the yellow HAZMAT alarm boxes if you believe there is an immediate danger to anyone in the lab. If you feel unsure about the danger, find another user to immediately contact staff for an assessment, while keeping other users out of the area.

- Call 119 as soon as you are safe to let emergency personnel know what happened. Stay available to help emergency personnel.
- If the spill caused serious injury or exposure, call 119.
- Move away from the accident scene and help keep others away.
- Do not walk into or touch any of the spilled substance. Try not to inhale gases, fumes and smoke. If possible, cover mouth with a cloth while leaving the area.
- Stay away from accident victims until the hazardous material has been identified.
- Try to stay upstream, uphill and upwind of the accident.
- Authorities may decide to evacuate an area for your protection. Again, it is important to stay calm, listen carefully and follow all instructions.
- If you are told to evacuate, make sure the evacuation order applies to you and to understand if you are to evacuate immediately or if you have time to pack some essentials. Do not use your telephone.
- If you are told to evacuate immediately, quickly and calmly take your personal belongings and medications, close and lock your windows, shut off all vents, lock the door.
- Return to building only when authorities say it is safe.

FIRES

In the event of a fire, lab users should activate the nearest pull station and evacuate the building.