

CLEANROOM SAFETY

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1. GENERAL SAFETY INFORMAYION

The Occupational Health & Safety Agency (OSHA) and The Environment Protection Agency (EPA) regulations require the training of all individuals exposed to potentially hazardous substances in the workplace. The Environmental Health & Occupational Safety (EHOS) will host safety seminars every semester. The lab attendants must take the seminars for getting trained. You can call extension 5080 for schedule.

This cleanroom safety guidelines and procedures describe the safety issues around the cleanroom, which are compliance with the Chemical Hygiene Plan of the City College of New York. The users of the cleanroom are encouraged to read the plan for more safety concerns around campus. Cleanroom is a site where the temperature, humidity, and particle density are under controlled. It provides a clean and special safety environment for handling semiconductor materials, fabricating and packaging electronic and photonic devices. It involves facilities using various materials. These materials could be toxic gases or hazard chemistries. In order to avoid unnecessary hurt or damage to the users, environments or facilities, it is important to have the general safety knowledge in mind and follow the protocol of the general operation in the cleanroom. This document sets forth those practices which are deemed good safety practices in a cleanroom environment.

1.1 General Safety and Operational Rules

A. General Operation Rules

1. Anyone wants to use any cleanroom facilities must read this safety manual and pass safety questions first.
2. Anyone using any cleanroom facility must be in advance specifically trained and certificated for operating any particular facility in cleanroom.
3. No one is allowed to enter the cleanroom without wearing cleanroom clothes.
4. Use solvent in solvent fume hood only and acid or base in acid fume hood only.
5. Always following the procedure of operating the facility. Make sure any gas/electricity/water is turned off if there is a requirement after you complete using the facility.
6. No button should be touched if you do not know the function of the button or you are not certificated to use the facility where the button is belonged.
7. Log in and out the log-notebooks of the facility you are used.
8. It is the responsibility of everyone working in the cleanroom to make certain that the facility is in their original status and the cleanroom is left clean after work is performed.

B. General Rules of Safety

1. Always wear cleanroom garments when you are in cleanroom to avoid contaminating the environment of the cleanroom and protect yourself from directly exposure to chemistries.
2. No running, jumping, or horseplay in the cleanroom areas shall be permitted
3. No faculty or staff or student shall work alone in cleanroom area when performing a task that is considered unusually hazardous.
4. Spills shall be cleaned immediately. Specifics of emergency spill tactics are provided in the Emergency Response chapter of this manual (Chapter 5). Small spills of liquids and solids on bench tops shall be cleaned immediately to prevent contact with skin or clothing.
5. Report immediately to the cleanroom supervisor if there is any unusually thing happens.
6. Follow the procedure of emergency response when an emergency accident happens.

C. Personal Hygiene

1. Wash promptly whenever a chemical has contacted the skin. Know what you are working with and have the necessary cleaning/neutralization material on hand and readily available.
2. Cleanroom clothing should be kept clean and replaced when necessary. Clothing should be replaced or laundered using appropriate decontamination procedures whenever contamination is suspected.
3. Never use "sniff-test" to identify a chemical; always use the label to identify a material.
4. No food, beverage, tobacco, or cosmetics products are allowed in the cleanroom or chemical storage areas at any time. Cross contamination between these items and chemicals or samples is an obvious hazard and should be avoided.

D. Housekeeping

As in many general safety procedures, the following housekeeping practices indicate common sense activities which should be implemented as a cleanroom daily maintenance.

1. Chemicals, especially liquids, should never be stored on the floor, except in closed door cabinets suitable for the material to be stored.
2. Reagents, solutions, glassware, or other apparatus shall not be stored in hoods. Besides reducing the available work space, they may interfere with the proper air flow pattern and reduce the effectiveness of the hood as a safety device.
3. Counter tops should be kept neat and clean. Bench tops and fume hoods shall not be used for chemical storage. All work done in fume hoods shall be performed in the "Safety Zone",

4. All containers must be labeled with at least the identity of the contents and the hazards those chemicals present to users. If the contents of all containers are known we will no longer have an unknown waste disposal problem.
5. Stored items or equipment shall not block access to the fire extinguisher(s), safety equipment, or other emergency items.

E. Electrical

A cleanroom usually requires a large quantity of electrical power. This increases the likelihood of electrically-related problems and hazards. One must address both the electrical shock hazard to the facility occupants and the fire hazard potential. The following recommendations are basic to a sound electrical safety program in the laboratory.

1. All electrical equipment shall be properly grounded.
2. Electrical cords or other lines shall not be suspended unsupported across rooms or passageways where repeated abuse can cause deterioration of insulation.

F. Vacuum Operations

In an evacuated system, the higher pressure is on the outside, rather than the inside, so that a break causes an implosion rather than an explosion. The resulting hazards consist of flying glass, spattered chemicals, and possibly fire.

1. Water, solvents, or corrosive gases should not be allowed to be drawn into a building vacuum system.
2. When the pressure of a vacuum chamber has not reach that of the outside, do not try to open the chamber.

1.2 General Safety Equipment

During the course of normal operations, the potential for accident and injury is always present. Adequate safety equipments in good shape are provided to limit the accidents and injury.

A. Fire Extinguishers

1. Fire extinguishers must be clearly labeled to indicate the types of fire they are designed to extinguish (link to the map of fire extinguishers).
2. Fire extinguishers should never be concealed from general view or blocked from access.

B. Safety Showers

A safety shower is set in the cleanroom to provide immediate and thorough washing of a body in case a user receives a chemical splash to his/her body.

1. Users should familiarize themselves with the location of the nearest safety shower (link to the location map).

2. Users should be familiar with the operation of the safety showers.
3. Safety showers are designed to flood the entire body in the event of a clothing fire or a major spill of a chemical. In either case, a person should simply stand under the shower and activate the shower. Flood the affected area for a minimum of 15 to 30 minutes.
4. In the case of a corrosive liquid spill, the person should remove the affected portion of clothing to reduce potential contact. Removal of clothing should be done while the individual is under the activated shower.
5. The emergency response procedure should be followed when a person required the use of the safety shower.

C. Eyewash Fountains

If a user receives a chemical splash to its eyes, immediate and thorough washing of the eyes should be done by using an eye wash fountain located near the wash showers.

1. Users should familiarize themselves with the location and operation of the nearest eyewash fountain.
2. Always flood the eyes for at least 15 to 30 minutes to be sure there is no residue of the corrosive liquid. Flush from the eye outward.
3. After thorough washing, the proper authorities should be notified and subsequent medical care for the person should be seriously considered. This is because serious damage may have already occurred before the eye was thoroughly rinsed and/or the damage may not be immediately apparent.

D. First Aid Kits

1. A first aid kit, which is located in gowning room, is to be used for immediate response to minor injuries, such as cuts or minor burns.
2. First aid kit contents include items such as Band-aids, sterile gauze pads, bandages, scissors, antiseptic wipes or ointments, and a first aid card.
3. The cleanroom supervisor is responsible for monitoring and maintaining the first aid kit. A log is attached to the kit indicating the last inspection date and by whom the kit was inspected.

E. Ventilation Hoods

1. Work that involves hazards and noxious materials which are toxic, odoriferous, volatile or harmful shall be conducted within the cleanroom hoods.
2. There are two hoods in the cleanroom. One is particularly for handling acids and the other one is for other solvent chemistries.
3. When not in use, the sash of the hood should be kept closed. While performing work in the hood, the sliding sash should be kept at the height designated to provide the minimum

face velocity required (usually 100 fpm). This will ensure maximum velocity of air flow into the hood and out of the cleanroom.

4. Only items necessary to perform the present experiment should be in the hood. The more equipment in the hood, the greater the air turbulence and the chance for gaseous escape towards you.
5. Always look to assure fan motor power switch is in the "on" position before initiating experiment.
6. Hoods shall not be used as a means of disposing of toxic or irritating chemicals, but only as a means of removing small quantities of vapor which might escape during cleanroom operations.

F. Flammable-Liquid Storage Cabinets

1. Store only compatible materials inside a cabinet.
2. Do not store paper or cardboard or other combustible packaging material in a flammable liquid cabinet.

1.3 Personal Protective Equipment

A. Eyewear

The type of eye protection required depends on the hazard. For most situations, safety glasses with side shields are adequate. Where there is a danger of splashing chemicals, goggles are required. More hazardous operations include conducting reactions which have potential for explosion and using or mixing strong caustics or acids. In these situations, a face shield or a combination of face shield and safety goggles or glasses should be used.

B. Clothing

Cleanroom garments and shoes are intended to keep the cleanroom clean, not the wearer safe. They do provide an extra layer of protection that may protect against minor spills and splashes. When using corrosive materials, a plastic or rubber apron should be used.

C. Gloves

Protection of the hands when working with solvents, detergents, or any hazardous material is essential in the defense of the body against contamination. Exposure of the hands to a potentially hazardous chemical could result in burns or skin damage.

Gloves of various types are available and should be chosen for each specific job for compatibility and breakthrough characteristics. There is no glove currently available that will protect a user against all chemicals. The excellent information is Guidelines for the Selection of Chemical Protective Clothing published by the American Conference of Governmental Industrial Hygienists (ACGIH) or information provided by glove manufacturers.

2. COMPRESSED GAS SAFETY

Cleanroom activity requires the use of compressed gases for facility operations, thin film deposition and etching. Gases may be combustible, explosive, corrosive, poisonous, inert, or a combination of hazards. If the gas is flammable, it presents a danger of fire or explosion. Additional hazards of reactivity and toxicity of the gas, as well as asphyxiation, can be caused by high concentrations of even "harmless" gases such as nitrogen. Since the gases are contained in heavy, highly pressurized metal containers, the large amount of potential energy resulting from compression of the gas makes the cylinder a potential rocket or fragmentation bomb. Therefore, careful procedures are necessary for handling the various compressed gases during their storage, transportation, and usage.

2.1 Identification

The contents of any compressed gas cylinder shall be clearly labeled for easy identification. Commercially available three-part tag systems can be very useful for identification and inventory. No compressed gas cylinder shall be accepted for use that does not legibly identify its contents by name. Color coding is not a reliable means of identification; cylinder colors vary with the supplier, and labels on caps have little value as caps are interchangeable. If the labeling on a cylinder becomes unclear or an attached tag is defaced to the point the contents cannot be identified, the cylinder should be marked "contents unknown" and returned directly to the supplier.

2.2 Handling and use

A. Since gas cylinders are tall and narrow, they shall be secured at all times to prevent tipping.

B. Cylinders containing flammable gases such as hydrogen or silane shall not be stored in close proximity to open flames. An open flame shall never be used to detect leaks of flammable gases. All cylinders containing flammable gases should be stored in a well-ventilated area.

C. Oxygen cylinders, full or empty, shall not be stored in the same vicinity as flammable gases. Greasy and oily materials shall never be stored around oxygen; nor should oil or grease be applied to fittings.

D. Every gas cylinder has its specified CGA connector. Make sure the right regulator with right CGA connector is used for a new gas cylinder.

E. A cylinder should never be emptied to a pressure lower than 25 psi.

F. Hydrostatic tests for metal fatigue are conducted every ten years by the supplier. Check the tested data before accepting the delivery.

G. Always use safety glasses (preferably a face shield) when handling and using compressed gases, especially when connecting and disconnecting compressed gas regulators and lines.

H. Check the safety, MSDS sheet and any warning label before using a gas.

2.3. Transportation of Cylinders

- A. To protect the valve during transportation, the cover cap should be screwed on hand tight and remain on until the cylinder is in place and ready for use.
- B. Cylinders should never be rolled or dragged.

3. Fire Safety

3.1 Fire Safety

The most common fire hazards in the cleanroom are flammable organic solvents such as acetone, isopropyl alcohol, and methyl alcohol. Only use these materials in the fume hood. If a fire is started, even if it is small, first ensure that there is an escape route. Then alert every one about the fire and pull the nearest fire alarm. If there is an injured person and you can remove the one from the area without danger to yourself, do so quickly. If you try to put out the fire, make sure you can access the escape route at all times. Be aware of any chemicals that may contribute to the fire or explode. If you are unsure whether attempting to put out the fire would be safe, just get out.

3.2 Fire Extinguishers

When using fire extinguishers, it is important to know the type of fire that is burning and the type of fire extinguisher appropriate for the fire.

Class A – Normal combustibles such as paper, cardboard, plastics, wood, cotton, etc.

Class B – Flammable liquids such as solvents, gasoline, oils, grease, etc.

Class C – Electrical fires

Class D – Combustible metals

Class K – Kitchen fires

The fire extinguishers near the cleanroom should be BC extinguishers and are adequate for most fires that might occur, but be aware since using an unfit extinguisher could make the problem worse.

3.3 Fire Extinguisher Location Map

4. Chemical Safety

Working in a cleanroom somehow means dealing with various potentially hazardous materials. There are three major routes of entry to chemicals: inhalation, skin absorption, and ingestion. Inhalation and skin absorption are the predominant occupational exposures you may expect to encounter in a cleanroom. Volatile solvents, toxic acids and bases are the common chemicals used during cleaning and etching semiconductor wafers. The particular hazards associated with exposure to these materials, and ways to avoid them, are discussed in below.

4.1 Solvent Safety

Organic solvents are perhaps the most ubiquitous chemicals found in a cleanroom. These chemicals are generally subdivided into two categories: chlorinated and non-chlorinated. The chlorinated solvents are, in general, not flammable and not water soluble while non-chlorinated solvents are often flammable and water soluble.

The primary route of exposure to these materials is through inhalation. In general, high concentrations of the vapor, when inhaled, produce drowsiness, dizziness and headaches. This can occur quite quickly, since chemical vapors are rapidly absorbed. Most of the solvents will also act as upper respiratory and/or eye irritants.

Chronic effects of solvent exposure vary widely. Of most concern is the potential for lung, liver, and kidney damage posed by some solvents. This, in general, applies to solvents. Examples of these solvents would be benzene, toluene, carbon tetrachloride, and trichloroethylene. Specified chronic disease related with the inhalation of solvents can be found in their MSDS.

One physical property common to most solvents is odor. However, the odor of a solvent cannot offer the judgment if the environment is immediately hazardous. As a general rule, one should avoid sniffing any odor from any solvent. Always use a well ventilated fume hood when using solvents.

Skin absorption is an additional mode of entry for which an exposure to a solvent may occur. Most commonly, solvents act to de-fat the skin. This will cause drying and cracking of the skin, and may lead to chronic dermatitis with prolonged and repeated exposure. Some solvents can also act as corrosives. Most amines and phenols act in this manner. Direct liquid contact by solvents in the eyes can be very serious. Get them to the eye wash immediately and flush the eyes for at least 15 to 30 minutes. Medical assistance should also be summoned.

Most skin contact with solvents can be avoided by wearing gloves suitable for that chemical. It is important that the glove be resistant to the material being handled. Using the wrong glove can give a false sense of security and overexposure via the skin may result. Rubber and neoprene gloves can be classed as good general purpose gloves, but a chemical resistance chart and the MSDS should always be consulted.

In summary, volatile solvents can pose inhalation, skin, and ingestion hazards. Some of the solvents may also be flammable, which could cause fire and/or explosion hazards. Whenever possible, use volatile solvents in a properly operating fume hood to eliminate inhalation hazards, use correct skin and eye protection and use good laboratory and hygienic technique to eliminate any possible ingestion of volatile solvents.

4.2 Acid and Base Safety

Common to all acids and bases is their corrosive action on human tissues. Exposure can occur through skin absorption or inhalation. Skin contact is the most common route of exposure. Wearing necessary safety equipments such as a safety goggles, face shield, neoprene glove, and apron when corrosive material is used. Most acid and base are water soluble. If there is skin or eye contact with acids or bases, make sure to flush the area with water for 15 to 30 minutes.

4.3 Chemical Waste

Under no circumstances is any person to dispose of a hazardous substance down the drain. Chemical waste must be disposed to labeled container according to its classification. Chemical waste procedure has to be in your mind before you dispose the waste. Right PPE has to be used for your safety purpose during dispose the waste. If there is a small amount spill, it must be cleaned up in order to minimize the fire hazard and the amount of vapors present in the lab. When a container is occupied over 80% its volume, use a new container and mark the old one. The CCNY Environmental Health Services Hazardous Materials Section is responsible for coordinating the pickup of surplus and waste chemical substances from the cleanroom disposal containers. Cleanroom's supervisor is responsible to call ESHMS at 5080 for making an appointment for waste pick up..

4.4 Chemical Materials Used in Cleanroom

Here is a list of chemical materials and their properties used in cleanroom. Before using a specific material, check its MSDS and be sure you know its hazardous and how to handle with it.

4.5 Material Safety Data Sheets (MSDSs)

A Material Safety Data Sheet (MSDS) is designed to provide both workers and emergency personnel with the proper procedures for handling or working with a particular substance. MSDS's include information such as physical data, toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill/leak procedures. These are of particular use if a spill or other accident occurs. MSDS usually comes with the material ordered. A list of these data sheets can be found in the location of ST502 and the links in section 4.4. You also can find MSDSs in internet such as

<http://www.ilpi.com/msds/index.html>

5. Emergency Response

During the course of normal operations there is always the potential for an emergency situation to arise. These emergencies can be the result of a chemical spill, fire, or the need for medical assistance. In the event of an emergency, internal communication is very important during any emergency situation. It is essential that all employees know how to act and react during the emergency. To accomplish this, it is necessary that a written Emergency Response Plan be developed and that all employees are trained and participate in drills. The emergency response plan is necessary to get the situation in control. The office of Environment and Occupational Health and Safety is in charge of making the policies and procedures of emergency response, providing training to lab personal and students, and auditing the emergency readiness levels.

5.1 Chemical Spills

Response to chemical spill will be according to the level of the spill. A spill could be minor or emergency.

A. Emergency Spills

A chemical spill is classified as an emergency spill whenever it causes serious personal injury, or chemical exposure, or fire emergency, or uncontrollable volatility, or building evacuation. In the event of an emergency spill, the following steps should be immediately taken:

1. Alert people in immediate area of spill.
2. Contact the Office of Environment and Occupational Health and Safety at 6961 or 5080. Have the location, building, floor, room number and the nature of spill. If no one can be reached, then call campus emergency at 7777.
3. Don't panic! Always send for help first, *if possible*.
4. If the spill presents an immediate danger, leave the spill site and warn others, control entry to the spill site, and wait for EOHS response.
5. Protect yourself, remove injured person to fresh air, if safe to do so.
6. Remove contaminated clothing. If skin/eye is involved, flush skin/eyes with water at least 15 minutes to 30; use soap for intermediate and final cleaning of skin areas.
7. If flammable vapors are involved, do not operate electrical switches unless to turn off motorized equipment. Try to turn off or remove heat sources, where safe to do so.
8. Do not touch the spill without protective clothing.
9. Never assume gases or vapors do not exist or are harmless because of lack of smell.
10. Where the spill does not present immediate personal danger, try to control the spread or volume of the spill. This could mean shutting a door, moving nearby equipment to prevent further contamination, repositioning an overturned container or one that has a hole in the bottom or side, creating a dike by putting an absorbent around a spill or opening the sashes on the fume hoods to facilitate removal of vapors.

B. Minor Spills

Minor spills are those spills which do not fit the requirements for emergency spills. Use protective equipment such as gloves to clean up minor spills. If the chemical is an inorganic acid or base, use neutralizing agent or absorbent mixture to neutralize and absorb it. If small amount of body is exposed to the spill, immediately flush with flowing water for at least 5 minutes.

5.2 Leaking Compressed Gas Cylinders

Occasionally, a compressed air may develop a leak. Most such leaks occur at the top of the cylinder in areas such as the valve threads, valve stem, and valve outlet. If a leak is suspected, do not use a flame or smelling for detection; rather, a flammable-gas leak detector or "snoop"

solution should be used. If the leak cannot be remedied by tightening a valve gland or a packing nut, one should consult with the supplier for instructions.

5.3 Fires

In the event of a fire, do the following things:

- A. Assist any person in immediate danger to safety, if it can be accomplished without risk to yourself.
- B. Immediately activate the building fire alarm system. This will automatically notify the Campus Police, EOHS, and sound the fire alarm bells or horns to evacuate the building. It is best to have these people respond and not to be needed than to have them arrive too late for potential rescue.
- C. If the fire is small enough, use a nearby fire extinguisher to control and extinguish the fire. Don't fight the fire if the atmosphere is toxic or the fire is out of control.
- D. If possible, safely shut off potential ignition sources such as ovens, electricity brake and close doors and windows to the fire.
- F. Do not use elevators; use building stairwells.
- G. When hearing the fire alarm sound, all personnel in the affected areas shall evacuate the building immediately.

5.5 Accident Reporting

ALL injuries shall be reported to laboratory management and the Office of Environmental and Occupational Health & Safety (EOHS). All accidents, regardless of severity, should be reported and investigated by safety and management personnel. The nature and the root cause should be thoroughly investigated. Taking corrective action as a result of accident may keep further incident from happening. If the accident involves overexposure to hazardous materials an Employee Exposure Report shall also be prepared and forwarded to EOHS.

6 Contact Information

Emergency contact information is listed in the following table

| Name | Person in contact | number |
|--|-------------------|-----------|
| Medical, Fire, or Police | | 7777, 911 |
| Campus Police | | 7777 |
| Student Health | | 7519 |
| Chemical Waste Disposal | | 5080 |
| Environmental Health & Occupational Safety | Graciano Matos | 5080 |
| Public Safety & Security | Pat Morena | 7991 |
| Cleanroom Supervisor | Prof. San-Hoo Seo | 7889 |

7 CLEANROOM PROCEDURE

7.1 Got Trained and Certificated

A cleanroom regulates air quality, temperature, and humidity to achieve the ideal manufacturing and experimental environment for high technology applications. The facilities in a cleanroom usually are expensive and their operations must follow certain procedures. In order to provide a safety and manageable fabrication environment, it is required for anyone to be trained and certificated before using any facility in the cleanroom.

7.2 General Regulations in Cleanroom

A cleanroom require specific attire, personal protective equipment (PPE), and the use of specialized equipment and chemicals. While modern air handlers manage the particle count, YOU are the best source to control cleanroom safety.

You are required to wear protective head, foot, and body coverings in a cleanroom to reduce particulate contamination. In addition, you must wear the required PPE to protect you from the materials and processes that you use. Eye protection such as safety goggles and glasses protect sight in the case of a chemical splash or uncontrolled reaction. Face masks and shields should be used for vacuum or pressurized processes if there is a danger of shattering or explosion. Use the appropriate gloves for the chemicals you handle in order to protect your skin. If necessary, you may need to wear a respirator to protect against airborne hazards. Remember that respirator use requires special medical qualification, fit testing, and training.

Be familiar with the cleanroom protocols and layout at your facility. Don't use equipment, materials, or processes that you are unfamiliar with; get the proper training first. Locate and understand the proper operation of safety equipment including fire extinguishers, safety showers, eye wash stations, and emergency shut off and bypass switches. Know the facility emergency signals, alarms, and evacuation routes and procedures. Know and follow compressed gas cylinder safety protocols; ensure that you are familiar with hazardous gas monitoring equipment and the associated alarms.

Chemical handling, including acids, bases, and solvents, is common in a cleanroom. Read and understand the material safety data sheets (MSDS) for the chemicals in the cleanroom to provide guidance on use, required PPE, spill procedures and disposal. If you are splashed with a chemical, immediately flush the area with copious quantities of water for 10 to 15 minutes and remove contaminated clothing.

Pay special attention to the use of hydrofluoric acid (HF) because skin or eye contact is extremely dangerous. HF exposures may not cause pain at first, but the fluoride ion continues to

burn through your tissue until it causes painful bone destruction. Rinse any suspected skin or eye contact immediately with water, and seek immediate medical attention.

Always conduct chemical processes under fume hoods or in designated wet benches, if possible. Practice good housekeeping with chemicals: clearly label containers, minimize quantities, and clean up materials after use. Ensure that chemicals are stored in rated chemical cabinets and are separated by hazard class. Know the spill procedures and the location of spill equipment in the cleanroom. Properly dispose of all chemicals, mixtures, and spill cleanup materials as hazardous waste in designated waste streams.

7.3 Operating Safely

Always follow the procedures when you working around the cleanroom. Your safety is the most priority when you doing your research. Never try to change, shorten, or skip the operating procedures for whatever the reason you have. Follow the emergency response if there is an accident happened. Stop, make the note and report the cleanroom supervisor immediately if something is wrong with the facility in the cleanroom.