# Table of Contents

Table of Contents ........................................................................................................ 1  
Preface .......................................................................................................................... 5  

**Section 1 Laboratory Overview** ................................................................................. 7  
  1.1 Information for New Users .................................................................................. 7  
  1.1.1 Information for New Academic Researchers .............................................. 7  
  1.1.2 Information for New Industry Researchers .............................................. 8  
  1.2 Facility Hours ...................................................................................................... 9  
  1.2.1 Building Hours ............................................................................................. 9  
  1.2.2 Nanolab Hours of Operation ....................................................................... 10  
  1.3 Facility Layout .................................................................................................... 11  
  1.3.1 First Floor Engineering IV ........................................................................ 11  
  1.3.2 Nanolab Map ................................................................................................ 12  
  1.4 Communication ................................................................................................... 13  
  1.4.1 Website ........................................................................................................ 13  
  1.4.2 Email ........................................................................................................... 13  
  1.4.3 Laboratory Phone System ........................................................................... 13  
  1.4.4 PA System .................................................................................................... 14  
  1.4.5 Computing ................................................................................................... 14  
  1.5 General Services ................................................................................................ 15  

**Section 2 General Cleanroom Policies** .................................................................... 17  
  2.1 Laboratory Access .............................................................................................. 17  
  2.2 Visitors ............................................................................................................... 18  
  2.3 Dress Code ......................................................................................................... 18  
      2.3.1 Street Clothes ............................................................................................ 19  
      2.3.2 Cleanroom Attire ..................................................................................... 19  
      2.3.3 Chemical Safety Attire .......................................................................... 20  
  2.4 Bringing Materials into the Cleanroom .............................................................. 20  
  2.5 Storage ............................................................................................................... 21  
  2.6 Billing ................................................................................................................ 21  
      2.6.1 Minimum User Charges ...................................................................... 22  
      2.6.2 Monthly Fee Cap .................................................................................... 22  
      2.6.3 Making changes to an account ............................................................... 22  
  2.7 Citation Suggestions ......................................................................................... 22  

**Section 3 Equipment Policies** .................................................................................. 24  
  3.1 Equipment Training ............................................................................................ 24  
      3.1.1 Overview .................................................................................................. 24  
      3.1.2 Procedure ............................................................................................... 25  
  3.2 Training for New Users ...................................................................................... 25  
  3.3 Advantages to Becoming a Super-User .............................................................. 26
3.4 Equipment Interlocks ............................................................... 26
3.5 Equipment Logbooks .............................................................. 27
3.6 Problems with Equipment ........................................................ 27
3.7 Reserving Equipment ............................................................. 28
3.8 Buddy System ............................................................................ 28
3.9 Process Repeatability and Reliability ........................................... 29

Section 4 Cleanroom Procedures ......................................................... 30
4.1 Cleanroom Garment Protocols ...................................................... 30
4.2 Bringing Items into the Cleanroom ............................................... 31

Section 5 Facility Hazards ................................................................. 33
5.1 Laboratory Hazards ................................................................. 33
5.2 Where to Find Chemical Information ........................................... 33
5.3 Terminology ............................................................................... 34
  5.3.1 Chemical Properties Terms .................................................. 34
  5.3.2 Types of Exposure .............................................................. 34
  5.3.3 Types of Effects .................................................................. 35
  5.3.4 Exposure Levels .................................................................. 35
  5.3.5 Toxic Effects ....................................................................... 36
5.4 Bringing New Chemicals into the Laboratory .................................. 36
5.5 Toxic and Corrosive Gases ........................................................... 37
  5.5.1 Silane ................................................................................ 37
  5.5.2 Chlorine and BCl₂ ............................................................... 37
  5.5.3 Anhydrous Ammonia .......................................................... 38
  5.5.4 Liquid Nitrogen .................................................................. 38
5.6 Highly Toxic Gases .................................................................... 38
  5.6.1 Phosphine .......................................................................... 38
  5.6.2 Dichlorosilane (H₂SiCl₂): ...................................................... 38
5.7 Toxic Gas Monitoring and Control System .................................... 39
5.8 Specific Chemical Hazards ........................................................... 39
  5.8.1 Acetone and Flammable Solvents ......................................... 39
  5.8.2 Hydrofluoric Acid ............................................................... 40
  5.8.3 Piranha Etch and Nanostrip .................................................. 42
  5.8.4 Tetramethylammonium Hydroxide ....................................... 42
  5.8.5 Chlorinated Solvents .......................................................... 42
  5.8.6 Glycol Ethers ................................................................. 43
  5.8.7 Peroxides .......................................................................... 43
  5.8.8 Pregnancy ....................................................................... 44
  5.8.9 Asthma, Rashes, or Unexplained Symptoms ....................... 44

Section 6 Using Wet Chemicals ............................................................ 45
6.1 Chemical Supplies ...................................................................... 45
6.2 Chemical Fume Hoods ............................................................... 46
6.3 Personal Protective Equipment .................................................... 47
  6.3.1 Chemicals Requiring Only a Face Shield .............................. 47
6.3.2 Apron ................................................................. 48
6.3.3 Face Shield ...................................................... 48
6.3.4 Chemical Gloves ........................................... 48
6.4 Chemical Hood Procedures .................................... 48
6.4.1 Working with Chemicals .................................. 49
6.4.2 Chemical Containers ....................................... 49
6.4.3 Container Labels ............................................ 50
6.4.4 24-Hour Rule ............................................... 50
6.4.5 Hot Plates .................................................. 51
6.4.6 Waste Disposal and Cleanup ........................... 51
6.5 Procedure for Point of Use Filtering of Photoresist .... 52
6.6 Chemical Handling Rules .................................... 52

Section 7 Hazardous Waste Handling .............................. 55
7.1 Chemical Waste .................................................. 55
7.1.1 Waste Storage ............................................... 55
7.1.2 Vented Caps ................................................ 57
7.2 Chlorinated Solvent Waste .................................... 57
7.1 Solvent Contaminated Items ................................. 58
7.2 Sharp Items .................................................... 58
7.3 Compound Semiconductor Waste ............................ 58

Section 8 Emergency Procedures .................................. 59
8.1 Using the Phones To Get Help ................................ 59
8.2 Emergency Response Equipment ............................ 59
8.3 Chemical Exposures .......................................... 60
8.3.1 First aid for HF burns to skin ......................... 60
8.4 Chemical Spills ................................................ 61
8.5 Building Alarms ............................................... 61
8.6 Fire ............................................................... 62
8.7 Earthquakes .................................................... 63
8.8 Incident Reporting ............................................ 63

Revision History ................................................................ 64
Acknowledgements ....................................................... 65
Appendix A : New User Application .............................. 66
Appendix B : User Action Form ..................................... 68
Appendix C : Nanolab Phone List .................................... 70
Appendix D : Chemicals Supplied by Nanolab ................... 72
D.1 Solvents ............................................................... 72
D.2 Acids ................................................................ 72
D.3 Bases ................................................................ 72
D.4 Etching Solutions ............................................... 72
D.5 Photolithography Chemicals ................................. 72
D.6 Evaporation Sources .......................................... 73
D.7 Sputter Sources .................................................. 73
D.8 Miscellaneous ................................................................. 73

Appendix E: Chemicals Requiring Only a Face Shield............................ 74
E.1 Solvents........................................................................... 74
E.2 Photolithography Chemicals...................................................... 74
Preface

Welcome and thank you for your interest in the UCLA Nanoelectronics Research Facility (NRF) colloquially referred to as the Nanolab. The Nanolab is a common-use cleanroom facility used for a wide range of micro and nano-fabrication projects. Inside the cleanroom is a variety of processing and measurement equipment created for the semiconductor-processing field. To use the laboratory, users pay a laboratory-usage fee as well as fees for using specific equipment. The majority of the Nanolab budget is derived from these user fees, which pay for the operation of the cleanroom. In addition to UCLA researchers, the laboratory allows outside academic users as well as users from industry.

The Nanolab is a community of researchers who share costly resources in a mutually supportive and egalitarian manner. To further this goal, users are expected not only to correctly and safely benefit from the resources in the Nanolab, but also to contribute to the laboratory by lending a hand to keep the facility running smoothly and efficiently. This can come in the form of professors providing oversight and equipment donations to the community and from users serving as superusers, participating on clean-up days, or making suggestions. All users are expected to help make the Nanolab a more capable, safe, and better place to work.

In order to maintain the egalitarian nature of the facility, Nanolab policies and staff attempt to treat all users equally and do not get deeply involved in specific user projects. The Nanolab therefore does not lay claim to or protect any intellectual property generated in the laboratory. The Nanolab is staffed with professional engineers who are tasked with developing and maintaining standard process recipes, maintaining equipment, writing and maintaining equipment documentation, and training users.

The standard processes that are developed for each piece of equipment are available for all users to take advantage of. However, users should be aware the processes are designed to work within a specific range of parameter values. If your processing needs fall outside the range covered by the “standard” processes, they may not work for you. You should consult the responsible engineer about how to achieve your desired results before attempting any non-standard processes. A list of primary and secondary engineers for each piece of equipment is listed on the equipment pages on the Nanolab website. As time allows, the engineers will work with you to develop a process that achieves the
desired results, but the user is ultimately responsible for performing the work necessary to develop the altered process.

Safety is an overriding concern in all Nanolab activities. All operations must be undertaken with the safety of both the individual user and other users as the primary consideration. As a general rule, anyone violating any safety rule or otherwise compromising his or her personal safety or the safety of others will have their access to the laboratory rescinded. Suspensions may be for several days, several weeks, or permanently. These suspensions are at the sole discretion of the laboratory management in consultation with the laboratory director and principal investigator of the project. Ignorance of the rules, lack of common sense, language difficulties, carelessness, and being short on time are not adequate excuses for unsafe behavior. In general, if a user is not certain on what the proper procedure is for something, it is better to stop and ask staff than to try and guess what to do.

It is the responsibility of all users and staff to act in a professional, respectful, courteous, and safe manner at all times while in the facility. Users violating the operating and safety rules of the facility or endangering the safety of themselves or other users may have their access restricted, suspended, or revoked as previously mentioned.

We would like to thank you for joining the Nanolab community. In this manual you will find information that new users should master to be safely and effectively utilize cleanroom resources. If you discover any typos or incorrect or out-of-date information, in this manual, please inform us so that we can correct the error(s). In addition, if you believe any part of this document or laboratory policy could be improved, please inform us. We are dedicated to making the Nanolab the best university-based cleanroom in the world.
Section 1
Laboratory Overview

1.1 Information for New Users

1.1.1 Information for New Academic Researchers

An orientation process is required before any new user can receive a badge to work in the Nanolab. The orientation process for academic users is a four-step process that generally takes two weeks to complete.

**Step 1:** Attend a new user orientation meeting. Meeting times and locations can be found on the Nanolab website at [http://nanolab.ucla.edu](http://nanolab.ucla.edu). Orientation meetings are held every 4 to 5 weeks and last approximately 2 hours. The purpose of the orientation meeting is to give an overview of the facility including policy, procedures, and safety information.

**Step 2:** Prepare the necessary paperwork for admission into the laboratory. Two pieces of paperwork are needed for this step;

1. The New User Application Form (Appendix A, or on the Nanolab website.)
2. A personal check for $25 made out to the UCLA EE Department for the account startup fee if the Professor, or PI declines to put it on the recharge ID.

Please make sure that the New User Application Form is filled out completely including P.I. signature. The completed paperwork should be brought with you to the safety test detailed in step 3.

**Step 3:** Take and pass the Nanolab safety test. The times for the safety tests will be scheduled during the orientation meeting but are generally scheduled for the week after the orientation meeting. Once scheduled, the date and time of the safety test will appear on the Nanolab calendar found on the Nanolab website. Safety tests are held in one of the Nanolab offices either 14-131A or 18-132M Engineering IV. The test is closed book and
usually takes under an hour to complete. Please bring the paperwork generated in step 2 to the safety test where it will be collected and reviewed. A user who fails the test must wait until the next monthly test to try again. Attending the orientation again is not required.

The test is based on knowledge of the materials contained in the Laboratory Usage Guide (i.e., what you are reading now), therefore, user should have completely read and understand the Laboratory Usage Guide prior to taking the test.

**Step 4:** Attend the Nanolab walkthrough. The time of the walkthrough is typically two weeks after the orientation and will be scheduled at the orientation meeting. Once scheduled, the date and time of the walkthrough will appear on the Nanolab calendar found on the Nanolab website. The walkthrough begins in one of the Nanolab offices either 14-131A or 18-132M Engineering IV and takes approximately 2 hours to complete. To participate in walkthrough, users must:

- Have attended the orientation session
- Have taken and passed the safety test
- Have a completed and submitted the New User Application form
- Have submitted a $25 personal check for the account startup fee (if required)
- Be appropriately attired for clean room access (See Section 2.3)

Badges will be handed out at the walkthrough and laboratory usage charges will commence. Following the walkthrough, users may enter the cleanroom at any time, but unless trained, cannot use equipment.

In the orientation process, the staff is looking for evidence that the user understands the language, rules, procedures, and consequences of working in the facility. The staff will evaluate whether the user can and will work safely in the laboratory. Actual approval for access is dependant upon the recommendation in these areas. The laboratory management may deny or restrict access, based upon this evaluation.

### 1.1.2 Information for New Industry Researchers

An orientation process is required before any new user can receive a badge to work in the Nanolab. The orientation process for industry users is a three-step process that generally takes two weeks to complete.

**Step 1:** Attend a new user orientation meeting. Meeting times and locations can be found on the Nanolab website at [http://nanolab.ucla.edu](http://nanolab.ucla.edu). Orientation meetings are held every 4 to 5 weeks and last approximately 2 hours. The purpose of the orientation meeting is to give an overview of the facility including policy, procedures, and safety information.
This step may be waived at the discretion of the laboratory management. This document must be read and understood before attending the walkthrough.

**Step 2:** Prepare the necessary paperwork for admission into the laboratory. Two pieces of paperwork are needed for this step;

1. The New User Application Form (Appendix A, or on the Nanolab website.)
2. A purchase order made out to the UCLA Nanoelectronics Research Facility for a minimum of $800.

Please make sure that the New User Application Form is filled out completely. The completed paperwork should be brought with you should be delivered or faxed to the Nanolab several days before step 3 the Nanolab walkthrough.

**Step 3:** Attend the Nanolab walkthrough. The time of the walkthrough is typically two weeks after the orientation and will be scheduled at the orientation meeting. Once scheduled, the date and time of the walkthrough will appear on the Nanolab calendar found of the Nanolab website. The walkthrough begins in one of the Nanolab offices either 14-131A or 18-132M Engineering IV and takes approximately 2 hours to complete. To participate in walkthrough, users must:

- Have attended an orientation session
- Have a completed and submitted the New User Application form
- Have submitted purchase order for a minimum of $800
- Be appropriately attired for clean room access (See Section 2.3)

In the orientation process, the staff is looking for evidence that the user understands the language, rules, procedures, and consequences of working in the facility. The staff will evaluate whether the user can and will work safely in the laboratory. Actual approval for access is dependant upon the recommendation in these areas. The laboratory management may deny or restrict access, based upon this evaluation.

### 1.2 Facility Hours

#### 1.2.1 Building Hours

The Nanoelectronics Research Facility is located in the Engineering IV building on the UCLA campus. Engineering IV is a secure building with doors being unlocked during the following hours of operation:

- **Monday-Friday** 7:30 a.m. - 11:00 p.m.
- **Saturday-Sunday** 8:00 a.m.- 8:00 p.m.
UCLA users should contact their department MSO to obtain a building keycard to enter the building after hours.

**1.2.2 Nanolab Hours of Operation**

The laboratory is open 24 hours a day, 7 days a week, including most holidays. Staff support is generally not available during weekends and university holidays. Certain instruments and procedures may have restrictions during evenings and weekends (See Section 3.8 regarding the buddy system).

The facility occasionally has intermittent closures due to variety of reasons such as unplanned facility maintenance issues, DI water outage, chemical spills, and other emergencies such as earthquakes. Typically unplanned closures last several hours.
1.3 Facility Layout

1.3.1 First Floor Engineering IV
1.3.2 Nanolab Map
1.4 Communication

1.4.1 Website

The Nanolab website can be found at http://nanolab.ucla.edu. The website contains information about the Nanolab, equipment, safety, training, and information for new users. In addition, LabRunner, an online calendar, reservation, training, and equipment activation system can be accessed through the Nanolab homepage. The Nanolab website contains a wealth of information and is designed to be a self-service resource for Nanolab users.

1.4.2 Email

Much of the communication between Nanolab staff and users is done through email. All users must supply the Nanolab with a functional email address that they actively check for messages. Users give this information during the orientation process.

In addition to communicating with individual users through email, all users are added to the Nanolab mailing list, nanoall@lists.ucla.edu. It is important to monitor email from this list, as it is the main source of announcements for training, lab closures, staff announcements, equipment problems, etc. Please do not use the nanoall mailing list to send messages directly to Nanolab staff or other Nanolab users.

If your email changes you will need to change it in two places, LabRunner and the nanoall mailing list. To change your email address in LabRunner, login, go to the profile page, click the box at the bottom of the page that says update, input a new email address, and then click save. To change your address in the nanoall mailing list go to the Nanolab homepage and select the link to the mailing list and follow the directions.

1.4.3 Laboratory Phone System

Telephones are provided throughout the cleanroom for the use by staff and users. There is a list of phone numbers containing emergency numbers, UCLA extensions for the Nanolab staff, intercom extensions, and laboratory extensions for many UCLA professors posted by each phone. This list is also available in Appendix C or online at the Nanolab website.

The laboratory phone system is accessible through external phone lines by dialing (310) 206-9597 from outside UCLA. On-campus phones can call the cleanroom directly by dialing the campus extension, 6-9597. When the laboratory is called from outside, all extensions will ring.
The telephones can be used to call outside of the cleanroom to emergency numbers and UCLA extensions only. Off-campus calls cannot be placed from these phones without a calling card.

To call another UCLA extension, simply dial the last 5 digits of the number (i.e. to reach the lab management number 310-206-8923, dial the extension 6-8923). To dial an external number, first dial 8, and then follow the directions on the calling card. In an emergency, dial 911 from any campus phone.

There is also an integrated intercom system, which connects the Nanolab, Microlab, and staff offices. It can be used even when the main line is busy and rings only the phone extension that is dialed (3 digits). To use, press the “Intercom” button and dial the three-digit phone extension. The extensions are posted by all of the telephones in the cleanroom.

Nanolab users are encouraged to answer the telephone when it rings. Exceptions to this are when a user is handling chemicals or loading a high-temperature furnace. If the call is not for you, please press the hold button and hang up the telephone receiver and page the person on the PA system.

Cell phones are allowed in all areas of the facility however use is restricted in the following manner. Handsets should only be used in the gown room to reduce laboratory contamination. Hands-free devices can be used throughout the laboratory however; they should not be used when working at chemical hoods or opening and closing vacuum chambers, furnaces or the e-beam writer.

1.4.4 PA System

The cleanroom area is equipped with an PA system to allow staff and users to locate each other while in the cleanroom as well as to announce evacuations in the case of an emergency. The PA system consists of wall-mounted microphones located throughout the laboratory next to the telephones. To use the PA system, simply flip the switch on the microphone to the ON position and speak into the top of the microphone. The most common use of the PA system is to alert a user that she has a phone call. Remember to switch the microphone off when finished.

1.4.5 Computing

The Nanolab has three classes of computers, General Use Computers, Equipment Activation Computers, and Equipment Specific Computers.

Equipment Specific Computers are dedicated computers that control a piece of equipment. This class of computer typically only runs the machine-control software on a
continuous basis. Users are not authorized to quit the machine-control software, install other software, or use a computer attached to a piece of equipment for any other purpose than running the tool. Because of the dedicated nature of machine control computers, they are not connected to the Internet nor do they have software updates applied.

**Equipment Activation Computers** are located throughout the laboratory. The Equipment Activation Computers are operated via a touch screen and have no keyboard or mouse. The sole purpose of these computers is to interact with the equipment reservation and activation system (often referred to as LabRunner). If the screen on one of these computers is blank, touch the screen to wake up the computer and login. Users are not authorized to quit the LabRunner software, install other software, or use a computer dedicated for equipment activation for any other purpose than interacting with the LabRunner software. After you are finished using an Equipment Activation Computer, please logout so that others can use it after you.

**General Use Computers** are located throughout the laboratory. General use computers are connected to the Internet. These computers are provided for general purpose computing tasks such as checking email, making equipment reservations, surfing the internet, checking mask files, etc. Users are not allowed to install software onto these computers including, instant messaging software, Google desktop, Yahoo desktop, viruses, etc. Users should not download files that are not necessary to completing work in the cleanroom such as music, photos, etc. Some of the general use computers are also able to capture microscopy images from nearby microscopes. A person taking images from a microscope attached to a general-purpose computer has priority over a user not taking images.

### 1.5 General Services

The Nanolab supplies a variety of in-house services and chemicals as part of the user fees. The most common in-house services users interact with are clean room garments (gowns, gloves, shoe covers, hair nets, safety glasses, and face masks), personal protective equipment (chemical aprons and face shields), dry nitrogen, and high purity deionized water (DI). High purity deionized water is available at all the chemical benches from the white goose neck faucets as well as spray handles. DI Water is expensive to produce and the use of it should not be wasted. DI faucets, dump rinse stations, aspirators, and cascade rinse stations should not be left running unnecessarily. Failure to turn off the DI water at one of these locations can result in depletion of the DI tank and a laboratory closure. Other in-house facilities used throughout the facility to support the equipment are cooling water, electricity, exhaust, and compressed air.

In addition to in-house facilities, the Nanolab supplies users with many of the commonly used chemicals user need when working in the laboratory. Chemicals supplied by the Nanolab have been filtered to remove any particulate matter and are semiconductor
grade. Examples of chemicals supplied by the Nanolab are: acetone, isopropanol, methanol, hydrochloric acid, sulfuric acid, hydrogen fluoride, photoresist, photoresist developer. For a complete list please refer to Appendix E.

Users are expected to purchase their own chemically resistant gloves and put their name on them with an indelible marker. The gloves should be stored on the shelf dedicated for their professor.
Section 2
General Cleanroom Policies

2.1 Laboratory Access

Access into the cleanroom portion of the laboratory is controlled through a badge issued to each user. Refer to Section 1.2 for building access. The badges serve as identification while in the laboratory as well as an access card. A card reader is mounted on the wall next to the entrance to the cleanroom. To enter the cleanroom, users swipe their badge in the card reader to unlock the door and enter the gown room. The door will remain unlocked for approximately three seconds and can be pushed open. After three seconds the door will lock again. The access card is also used to log laboratory usage for billing purposes. Once the badge is swiped in the card reader, the system logs the amount of time the user is in the cleanroom until the user exits the cleanroom. To exit the cleanroom users swipe their badge in the card reader mounted on the wall on the inside of the gown room. As the badges serve as identification while in the laboratory, users are required to wear their badge on the outside of their gowns.

Sharing of badges or permitting unauthorized access to the facility is not allowed. Because the badge is essentially the “key” to the cleanroom, it should be treated like one’s own house or car keys. If you lose your badge please notify the laboratory management immediately so that we can disable it.

Persons without access cards specifically issued to them are not allowed in the facility, except for brief tours accompanied by an authorized user (See Section 2.2). Your badge is essentially your documentation that you have received the required orientation and safety training. Non-authorized persons are thus prohibited from accompanying, observing, and helping users at work. Non-authorized persons are thus also prohibited from the role of laboratory “buddy”. Please see Section 3.8 regarding the buddy system. Lending an access card to someone else is a serious violation.
The status of a user can be changed by submitting the User Action Form found on the Nanolab website and in Appendix B. A change of status may include termination of a user badge, change of PI, badge suspension, change of account number, change of email, and others. Please print and complete the form and submit it to the laboratory management.

In addition to providing physical access to the cleanroom, the number printed on the bottom of the badge is used to login to the secure portion of the Nanolab website as well as the Equipment Activation Computers throughout the cleanroom.

2.2 Visitors

Tours of the cleanroom should be limited to valid technical visitors such as sponsoring agencies, collaborators, and prospective researchers. Sufficient view of the facilities for all but serious visiting scientists can be obtained from the public hallways outside the cleanroom.

Tours should be limited to a walk through of the facility, last no more than 1 hour in length, and should not include any chemical processing, furnace loading or any operation that may be dangerous or require extreme cleanliness. The purpose of a tour is to give the visitor an overview of the processes and types of equipment available in the facility not for instruction in processing techniques or how to operate equipment. Visitors must be cleared with Nanolab management prior to the cleanroom tour. For safety reasons, tours should be limited to no more than three people.

When entering the cleanroom visitors must be properly gowned, including eye protection, and follow the same protocols as regular users. It is important to remember that the user is responsible for the actions and safety of their guests when touring the facility. For repeat visitor or large groups there is a nominal charge per visitor to cover the cost of hairnets, shoe covers, gloves, cleaning of the gown, etc.

2.3 Dress Code

The dress code for working in the cleanroom is based on considerations of safety and cleanliness. The dress code is based on standard practices when working in clean areas that contain hazardous materials. The three components of the dress code include the street clothes that are worn under the cleanroom garments, the set of necessary cleanroom attire, and the personal protective equipment required when working with chemicals.
2.3.1 Street Clothes

In general, a user’s clothing should be clean before entering the cleanroom. Users should not come to the facility with clothing that is dusty or dirty from previous work. Users should also avoid clothing that tends to shed a lot of fibers like fur, fake fur, mohair, etc.

Shirts must be worn and must extend from the top of the arms to the pants. Tank tops, halter-tops, and spaghetti strap tops are not allowed.

Pants must extend from the shirt to the ankles. Shorts, short pants, skirts, and dresses are not allowed. In the summer months, putting on hospital scrubs over the top of shorts is popular.

Shoes must be closed toe shoes that fully enclose the heel and top of foot. High heels, sandals, open weave shoes, or shoes that expose the top of the foot are not allowed.

Caps, hats, and sunglasses are also not allowed.

2.3.2 Cleanroom Attire

When entering the cleanroom users are required to cover their street clothes with special cleanroom compatible garments. The purpose of these garments it to protect the cleanroom from contamination. The cleanroom garments are not intended to protect the user from any hazardous materials found in the laboratory. The following list of garments must be worn in the cleanroom at all times:

- Hairnet or bouffant cap
- Eyeglasses, safety glasses, or goggles
- Face mask (during designated operations)
- Gloves
- Cleanroom gown or jumpsuit
- Shoe covers or cleanroom boots

A description of gown room procedures and policies is given in Section 4.1.

Safety glasses or goggles must be worn at all times in the laboratory. Safety glasses are supplied in the gown room for users who do not wish to purchase their own. If you wish to purchase your own safety glasses they should meet the ANSI Z87.1-1989 standard and be approved by laboratory management.

Safety glasses may only be removed when using optical microscopes. Users should be sure to remember to put them back on when they step away from the microscope. Safety glasses are not a substitute for face-shields when working with chemicals.
Contact lenses are allowed in all areas of the facility, however users wearing contacts are required to wear goggles in place of safety glasses.

2.3.3 Chemical Safety Attire

When working with chemicals in the cleanroom, users are required to wear the following personal protective equipment:

- Chemical apron or smock (supplied by the Nanolab)
- Chemical visor or face shield (supplied by the Nanolab)
- Chemical resistant gloves (supplied by the user)

More information about chemical safety can be found in Section 5

2.4 Bringing Materials into the Cleanroom

Users are allowed to bring most materials into the cleanroom with a few restrictions:

No food or drink is allowed in the cleanroom, this includes chewing gum, cough drops, mints, candy, chewing tobacco, and etc. Eating and drinking is not allowed in the cleanroom with the exception of the drinking water supplied in the gown room.

Items not allowed in the laboratory are:

- Pencils
- Wood
- Cardboard
- Any material that will continuously shed particles

Chemicals not found in the MSDS book located in the yellow binders next to the gown room are not allowed in the laboratory without approval of the laboratory management. See Section 5.4 for more information.

Other materials brought into the laboratory should be blown off with a nitrogen gun to remove particles and wiped with isopropyl alcohol to remove finger oil. Users wishing to bring laptop computers or other expensive equipment into the laboratory should be aware that they bring such items into the laboratory at their own risk. The Nanolab does not guarantee that items brought into the laboratory will not be stolen. Equipment such as hotplates, power supplies, etc. brought into the laboratory must be approved in advance to determine location and duration.
2.5 Storage

Cleanroom space is a scarce resource; therefore, large amounts of storage are not available. A limited amount of storage space is made available to researchers. Typically a professor or company will be assigned a shelf in one of the storage cabinets located along the periphery of the laboratory. The shelves should be used only for keeping currently needed samples, masks, and tools. Please do not store unnecessary items such as, old samples, old masks, and unneeded samples.

No chemicals of any kind may be stored in user storage areas. Chemicals are to be stored only in the appropriate chemical cabinets. No additional dry boxes, desiccators, cabinets, etc. may be left in the laboratory without permission.

All items in the cleanroom should be clearly labeled with the user’s name and the name of the user’s research group and phone number. The staff periodically disposes of things left unlabeled, or belonging to inactive researchers.

2.6 Billing

All users of the Nanolab are charged by the hour for the use of the laboratory. The laboratory usage is determined from the badge system used to enter the cleanroom. In addition users are charged by the hour for equipment usage. Equipment usage is determined from both the LabRunner system and entries in the logbooks. Some expendables such as precious metals are charged by the amount used. The current rates for laboratory time and equipment charges can be found in the current rate sheet. User fees pay for the operations of the Nanolab including staff, expendables, equipment maintenance, and upgrades.

The Nanoelectroics Research Facility has a three-tiered rate system. UCLA, non-UCLA academic and non-academic users are charged at different rates. Current rates can be found by contacting Nanolab management. Non-academic rates are chosen to be comparable to those charged by commercial suppliers of equivalent services, where applicable, and to cover the full cost of operation. Academic user fees are for bona-fide academic research only by students, post-doctoral researchers, and full time university staff members. Employees of companies may not use visiting scientist status at UCLA or elsewhere to receive academic rates. However, if a faculty member designates this work as collaboration, the facility may request the academic rate. Assignment in questionable cases is at the discretion of the management.

Users will be billed at the end of each month for accumulated user charges. For users within the University of California, a billing statement with a break down of charges is
sent to the managing professor or PI each month. The billing statement is informational and requires no action as funds are directly withdrawn from the account on file via a journal voucher. Non-UC users will be sent an invoice each month with a break down of charges. Non-UC terms are typically Net 30. External users must supply a purchase order number against which charges can be billed. Failure to pay user charges will result in suspension of the badges associated with the account.

2.6.1 Minimum User Charges

There is a minimum monthly charge for both academic and non-academic users. User fees accumulated for a given month are applied to the minimum charge for that month. This means that when a user uses the facility and accumulates charges that are below the minimum, the user will be charged the minimum.

For academic users the minimum monthly charge is per badge and is in effect even if the user does not enter the cleanroom. For non-academic users the minimum is per company and is not charged if there is no laboratory use for a given month.

2.6.2 Monthly Fee Cap

In recognition of the value of intense users and to allow easier budgeting, the Nanolab has implemented a monthly cap on user fees. The fee caps are split into two components, laboratory usage fees and equipment usage fees. Academic and non-academic users have a cap on the amount of lab usage an individual user can accumulate. Academic users have a cap on the amount of equipment charges an individual user can accumulate. Certain materials and processes such as photomasks, the e-beam writer, FIB, and LPCVD, do not fall under the caps. For a complete list of capped items and current cap rates, please refer to the current rate sheet.

2.6.3 Making changes to an account

Users need to, in writing, notify the Nanolab staff of any change to their account numbers or user status. The User Action Form handles most user changes including badge suspension, badge termination, badge reactivation, PI change, account number change, and email changes. The User Action Form can be found on the website or in Appendix B. Please complete the form and submit it to the Nanolab staff.

2.7 Citation Suggestions

Although not required, the Nanolab would appreciate an acknowledgement in research publications that have devices fabricated in the Nanolab. The goal of such an
acknowledgement is to promote UCLA and Nanolab facilities for the betterment of the University. An example of an acknowledgment is given below:

“The authors would like to thank the Nanoelectronics Research Facility at the University of California Los Angeles for making the fabrication of this device possible.”

If you choose to acknowledge the Nanolab, thank you, we appreciate it.
Section 3
Equipment Policies

After a user has completed the orientation process, been issued a badge, and can enter the cleanroom, the user is generally not qualified to use any of the processing tools and must undergo additional training. Most of the equipment in the cleanroom is setup to be operated by users rather than equipment operators. Although there are no dedicated operators to run processes for users, each piece of equipment is under the responsibility of two staff members. One of the responsible engineers is the principal engineer and the other a backup secondary engineer. Current equipment responsibilities can be found on the equipment pages in LabRunner.

Engineers are generally responsible for process development, tool maintenance, and training. Equipment policies regarding allowed and prohibited operations on the tool are developed by the responsible engineers and laboratory management and set down in the written operating procedure for that tool. Operating procedures, or specs, can be found in the equipment logbooks as well as on equipment pages in LabRunner. Violation of the written procedures or careless operation can result in damage to the equipment, downtime and considerable expense. Therefore, careless use leading to equipment damage will result in possible suspension of user privileges, charges related to equipment repair, and require the user to perform additional laboratory service.

3.1 Equipment Training

3.1.1 Overview

Before using any piece of equipment in the Nanolab, users must undergo additional training specific to that piece of equipment. Depending on the complexity of the tool there is either one or two training sessions. Highly complex equipment may have more than two sessions. The number of sessions that a particular tool requires is shown on the equipment pages in LabRunner.

For efficiency, a group of typically six users are trained at one time in the first training session. In the first session the super-user or responsible engineer shows the users how to
operate the equipment by following the operating procedure and pointing out additional processing rules and potential pitfalls. For less complex equipment this first training session is all that is needed for the user to start using the equipment.

For more complex equipment, a qualification or certification training is required of all users. The second training session is a one-on-one session where the user demonstrates that they can operate the tool in an independent fashion. The super-user or engineer watches the user independently operate the tool and evaluates whether or not the user can safely use the tool without supervision. It is recommended that a qualification run be scheduled when the user has a real sample to process. In this way the user can get advice on the best recipe to use and potential pitfalls related to their specific sample.

### 3.1.2 Procedure

The first level of equipment training sessions occur as demand dictates and are organized by the laboratory training coordinator. A training session is normally initiated through a user request to the training coordinator through an email to:

nanotraining@nanolab.ucla.edu.

Once a training session is initiated the slots are offered to users based on their position on the training waiting list in LabRunner. Slots are offered to the top six users on the wait list via an email announcement. If a user would like to attend the training session, they can accept the training invitation in LabRunner home screen. Users should decline training sessions that they cannot attend in the LabRunner home page.

If the training session is not full after invited users respond to the training invitation, a general email is sent to the nanoall mailing list stating the number of open slots at the training session. If a user would like to take one of the open slots they should email the training coordinator at nanotraining@nanolab.ucla.edu and request the slot.

When attending training, users should print out and review the operational protocol or spec for the machine. At the date and time of the training the users to be trained should enter the cleanroom and go to the machine, bringing with them the operational protocol. Users must arrive to training sessions on time. If you need to cancel please notify the training coordinator so that another user can take your training slot.

### 3.2 Training for New Users

New users often need to be trained on many pieces of equipment as soon as possible. This is not a unique or new situation and while we try to hold training session soon after the laboratory walkthroughs, the fact is that getting training on many pieces of equipment takes time. There are some things new users can do to move the process along.
After attending the walkthrough, new users should immediately login to LabRunner and signup for training for all of the equipment that they expect to use in the Nanolab. Do not signup for every piece of equipment, just the ones that you need. After placing yourself on the waitlist for your desired equipment, compose an email to nanotraining@nanolab.ucla.edu stating what equipment you would like to be trained on as well as the priority of each tool.

If you see that there is a training session for a tool that you need and you are not on the training list, it is OK to go the training session and see if the trainer will let you attend or if someone does not show up.

3.3 Advantages to Becoming a Super-User.

A Nanolab super-user is a regular Nanolab user who has received additional training on a processing tool so that they can train other users on that tool. Users are encouraged to become super-users. Not only will you provide valuable service to the laboratory, you will also demonstrate that you are a responsible and dedicated laboratory member by giving back to the laboratory. In addition being a super-user has the following benefits.

For every hour of training time you receive:
- A laboratory usage credit so you are not paying to train others.
- An additional laboratory usage credit as a way of paying you for your service.
- An additional machine credit for chargeable equipment as a way of paying you for your service.
- Priority on equipment training lists so you don’t have to wait as long to be trained on equipment that you need to use.
- The ability to train others in your laboratory without holding an public training.
- Periodic parties held by staff to acknowledge superuser contributions.

3.4 Equipment Interlocks

The Nanolab uses a computer-based system to control equipment access and to also record equipment usage charges. Dedicated touch-screen terminals located throughout the laboratory are used to activate and deactivate equipment. User should use their LabRunner login and password to activate the touch-screen equipment activation computers. If logging in for the first time, your user name is the badge number located on the front side of the badge and the password is nanolab. Note that the user login should not have the leading zeros included, for instance badge number 001434 would use 1434 as the login name. Use of the LabRunner system will be demonstrated during the laboratory walkthrough portion of the orientation process.
LabRunner does not actually turn on the power to equipment, but rather enables or
disables the instrument interlock to enable the user to use the equipment. Users may be
logged onto several instruments at once and they may log off them individually. Users
must remember to log off equipment once they finish or they will continue to accumulate
equipment charges.

Note: you may activate or deactivate a tool from any of the touch-screen terminals
located in the laboratory.

3.5 Equipment Logbooks

Each piece of equipment has a logbook associated with it. Users must fill out the
information in the logbook every time a piece of equipment is used. You will be shown
how to fill in the logbook during equipment training. The information provided by the
user entries in the logbook is necessary component of documenting equipment usage. The
engineer responsible for a piece of equipment will monitor the log entries several times a
day in order to determine the status of the equipment, problems users may be
experiencing, and process drift. Accurate and complete information is necessary for the
engineers to keep the equipment running and identify small problems before they become
big problems.

3.6 Problems with Equipment

Problems with the operation of the equipment should be reported to the principal
equipment engineer in charge of the tool. If the problem occurs during staff hours calling
the equipment engineer on the phone or finding them in the laboratory is the best
solution. If the problem is after hours, it is important to send an email to the engineer
describing the problem. If the principal engineer is unavailable due to illness or vacation,
contact the secondary equipment engineer.

For equipment that is not operational or may be dangerous to continue operation, such as
having a wafer stuck in the chamber, the user should prominently attach a note to the
front of the tool describing the situation. This makes certain other users going to use the
equipment are warned of the problem and not to use the equipment. If the problem occurs
after hours, the user will have to wait until the next business day for a resolution.

In no cases should a user attempt any repairs to the tool beyond what is explicitly allowed
in the operating instructions for the tool. As with all things, if a user is uncertain if it is
OK, they should check with staff before taking action. The equipment in the facility is
very expensive and much of it is very delicate. Considerable damage can be done at a
great cost of both money and downtime by careless attempts to fix things.
Users should not call the staff at home in the evenings or on weekends about problems with the equipment or their process. It will have to wait until the next workday. Obviously, major problems like fire, smoke, significant water leaks, or alarms should be reported immediately.

3.7 Reserving Equipment

Equipment can be reserved for a specific period of time through the Labrunner system. Equipment reservations give the user priority for using the tool and are provided as a means to efficiently schedule heavily used equipment. The system is web-based and accessible from any computer with a web connection. Most equipment has a maximum amount of time, typically 3 hours, a user can reserve the tool in a given day. This restriction is to allow all users access to a tool within a reasonable time span.

If a user is going to be late for a reservation, they should delete and reschedule their time on the tool. In order to reduce last minute cancellations, users are not allowed to cancel a reservation within two hours of the beginning of the reservation. In the event a user needs to cancel the reservation during the two-hour period before the start of the reservation, the user should send a message to the nanoall mailing list, nanoall@lists.ucla.edu, to notify other users as to the cancellation. The Nanolab understands that all projects require a certain process flow between instruments so that one problem can throw off an entire process schedule. Also, processes can take longer than anticipated. Thus while it is encouraged to sign up ahead of time, users should also be flexible and cooperative with other users in stretching, sharing, and relinquishing time slots. Users who repeatedly cancel reservations after the two-hour deadline will be charged the minimum usage fee for that tool if no one uses the tool in their place.

If a user is more than 15 minutes late for his or her reserved time on a tool, the reserved time may be claimed by anyone in the lab.

3.8 Buddy System

The laboratory is open for most use 24 hours a day, 7 days a week. Use of the laboratory requires that two users be in the cleanroom at all times. During normal staff hours this requirement is generally satisfied by the presence of the staff. Outside normal business hours it is necessary to ensure that you are not working alone in the laboratory. It is the users responsibility to coordinate with another user to ensure that two people are in the laboratory.
3.9 Process Repeatability and Reliability

The Nanolab is a shared use facility where users perform a wide variety of research. Because of this, the process flows and projects that users perform in the laboratory are quite varied. The minimum feature size, photoresists, etch depths, number of layers, layer composition, open area, backside condition, cleanliness, metals, etch stops, masking materials, chemistry, etc are different from user to user.

For a processing tool to give reliable and repeatable results, not only do the processing parameters and conditions need to remain constant from run to run, but also the condition of the processing chamber. There is an interplay between the machine condition, wafer preparation, and processing parameters that make a process stable and reliable. If you change any one of these factors the end result of the process will most likely be somewhat different.

When processing inside the Nanolab users have direct control over the processing parameters and wafer preparation, but often do not have much information about the internal condition of the processing chamber. The condition of the processing chamber is particularly important for etch tools. Over time the performance of processing equipment degrades due to build-up of processing by-products. For equipment to run in peak performance it needs to be periodically cleaned, both physically, by scrubbing the chamber by hand and chemically by running the tool with a cleaning recipe.

The Nanolab staff performs periodic physical cleaning of the tools, but users can perform the chemical cleaning of the chamber, generally accomplished by running an O₂ plasma in an RIE machine. While cleaning helps to remove unwanted material from the process chamber, the cleaning process leaves the chamber in an unstable state, which starts to change as a regular process is run in the machine. For this reason, it is typically necessary to perform a conditioning or seasoning run to eliminate this first wafer effect for your samples.

In a seasoning run, the chamber is lightly coated with the by-products of the real processing recipe. The conditioning run should be run using the same recipe and wafer preparation as the next lot of wafers to be run. After a conditioning run you can be relatively sure that the condition of the chamber is in a known, reliable, and well-controlled state. In order to confirm that the tool will generate the expected results, a process monitor wafer should be run to verify the etch rate, deposition rate, etc. Only then can you be confident that the tool will give the expected results for the next wafers in your lot.
Section 4
Cleanroom Procedures

In order to enter the cleanroom, users must be properly dressed and follow the procedures for gowning in order to avoid generating unnecessary particles. Proper cleanroom etiquette is important to ensure the cleanliness of the cleanroom and maintain the ability to perform state-of-the-art experimental work. Section 4.2 covers the general dress code for the facility. Even if a user determines that their work is not sensitive to particles, it is important to recognize that this is a shared-use environment where other researchers need a clean facility. If you are uncertain what the proper protocol for a situation is, talk with staff before proceeding.

Every time material is brought into the cleanroom, contamination is carried along with it. One aspect of maintaining the cleanliness of the cleanroom is to minimize the amount of material brought into the facility. Therefore, only items needed should be brought into the cleanroom. Section 2.4 covers the items that are expressly forbidden from the cleanroom. It is important for the user to become familiar with these restrictions and come appropriately prepared for working in the cleanroom.

4.1 Cleanroom Garment Protocols

A cleanroom suit consists of three parts: a hair net, a gown, and shoe covers. Proper gowning technique is important to ensure the cleanliness of the garments and the facility. Before entering the cleanroom, users should make certain they meet the clothing requirements listed in Section 2.3.

The gown room consists of a dirty area and a clean area separated by a bench. When you enter the gown room you will be on the dirty side where street shoes can be worn. On the other side of the bench, is the clean area, only shoe covers should be worn on this side of the gown room. Do not store anything in the gownroom such as coats, backpacks, hats, umbrellas, etc.. It should be noted that the cleanroom suit is not designed to protect users from potential hazards in the cleanroom, but rather to protect the cleanroom from
particles generated by the users clothing, skin, and hair. Protective safety equipment must be worn when handling chemicals.

To enter the cleanroom:

1. Step on the tacky mat outside of the cleanroom entrance to remove dirt from the bottom of your shoes. Don’t worry if it looks dirty, it is still working.
2. Enter the cleanroom using your Nanolab badge and place all items being taken into the cleanroom on the counter.
3. Put on a hair net and safety glasses or goggles located by the entrance window.
4. Put on shoe covers and step over the bench to the clean side of the gown room.
5. Put on the cleanroom gown being careful not to drag the gown on the floor in the process.
6. Put on gloves and tuck the sleeves of your gown into the gloves.
7. Put on a facemask if required.
8. Retrieve any materials on the counter
9. Open the door to the clean room and step on the tacky mat as you enter the cleanroom.

Once in the cleanroom, the cleanroom suit should never be opened or unzipped. If something under the suit is needed, return to the gowning room to open the suit and retrieve it. Anything that a user needs access to while in the cleanroom (i.e. cell phones, iPods, PDAs, etc.) should be taken out while in the gown room and wiped down with isopropyl alcohol. If your safety glasses get dirty there is a lens cleaning station in the gown room.

When exiting the cleanroom, reverse the steps used to gown. Place the gown on a hanger and label it by writing your name on a piece of tape and attaching it to the hanger. Snap the boots to the bottom of the pant leg. Throw away the facemask, gloves, and hairnet. Continue to reuse the gown upon each entry. Every two weeks a section of the gowns are sent out for laundering. If you find that your gown is no longer there and has been laundered, use a new cleanroom suit to gown. When using a gown for the first time, it should be inspected for holes or tears, do not worry about stains or discoloration.

### 4.2 Bringing Items into the Cleanroom

Users are allowed to bring many materials into the cleanroom, but there are a few restrictions. No food or drink is allowed in the cleanroom, this includes chewing gum, cough drops, mints, candy, chewing tobacco, and etc. Eating and drinking is not allowed in the cleanroom with the exception of drinking the Nanolab-supplied water in the gown room.
Items not allowed in the laboratory are:

- Pencils
- Wood
- Cardboard
- Any inherently dusty material

Chemicals not found in the MSDS book located in the Nanolab are not allowed in the laboratory without approval of the laboratory management. See Section 5.4 for more information.

Other materials brought into the laboratory should be blown off with a nitrogen gun to remove particles and wiped with isopropyl alcohol to remove finger oil. Users wishing to bring laptop computers or other expensive equipment into the laboratory should be aware that they bring such items into the laboratory at their own risk. Items should be labeled and if possible, password protected. The Nanolab does not guarantee that items brought into the laboratory will not be stolen.
Section 5
Facility Hazards

5.1 Laboratory Hazards

The Nanolab uses various chemicals that can pose a health hazard for users. These laboratory chemicals generally fall into two categories: gases and wet chemicals. There are also some hazardous solids such as sharps, GaAs and XeF$_2$. Many processing tools in the facility use compressed gases to operate, some of which are toxic, highly toxic, corrosive, flammable, or explosive. Due to the hazards posed by these gases they are strictly contained and controlled because an accident with these gases can be catastrophic. The hazards created by compressed gases, however, are greatly minimized by the use of proper equipment, proper confinement, ventilation, sensors, purges, safety valves, etc.

Wet chemicals present a more troublesome category of hazard. Users commonly use acids, bases and solvents in a “hands on” way, and therefore, the risks are in the hands of each individual user. Because many wet chemicals are considered common and are used routinely by many users, they present a serious hazard due to familiarity and reduced vigilance of safety procedures. Many of the wet chemicals commonly used in the facility can cause severe burns, tissue damage, organ damage, asphyxiation, and genetic damage if improperly used. These chemicals can enter the body by inhalation, ingestion, or absorption (either directly through the skin or through gloves) and may have either long or short-term health consequences. In addition, improper use of solvents can result in a major fire. In short, ordinary, routinely used wet chemicals in the laboratory are not hazard free. Users are expected to treat all chemicals with appropriate respect, and to be aware of all possible reactions, which may be created, either intentionally or by accident.

5.2 Where to Find Chemical Information

The Materials Safety Data Sheet (MSDS) is a convenient, condensed source for information on the properties of chemicals. The MSDS is a federally mandated
document, which must be supplied by the manufacturer or vendor of a chemical. It contains in summary form, the chemical composition, the physical and chemical properties, toxicology data, and instructions for handling, spill control, and waste disposal. Users must read the MSDS for every chemical that they handle inside the cleanroom. Safety data sheets for all chemicals approved for use in the laboratory are available in the yellow binders at the entrance to the cleanroom. Online MSDS sheets can be found at http://ucmsds.com.

5.3 Terminology

The following terms are routinely encountered when researching the properties of a chemical in an MSDS sheet. Simple definitions are included here to help understand the properties of common chemicals when referring to the MSDS or other references. This is not intended to be a complete reference on Toxicology or Chemical Safety.

5.3.1 Chemical Properties Terms

**Pyrophoric** chemicals spontaneously ignite in air. No source of ignition (spark) is needed as they react spontaneously when exposed to oxygen. Silane is an example of a pyrophoric gas used in the facility.

**Flash point** is the minimum temperature of a liquid at which it gives off sufficient vapor to form an ignitable mixture with air. Liquids with a flash point near room temperature can be ignited very easily during use.

**Exothermic Reaction** is a reaction that produces heat. Mixing acids and solvents typically produce a exothermic reaction vigorous enough to spray the mixed contents.

5.3.2 Types of Exposure

**Acute Exposure** refers to a short-term exposure.

**Chronic Exposure** refers to a long-term exposure.

Acute and Chronic exposures have nothing to do with either the severity of the exposure or the severity of the effect. An example of an acute exposure would be the type of exposure occurring during an accidental chemical spill. Chronic exposures can be the result of chemicals in the workplace, the home, or the environment. Chronic exposures are usually the result of carelessness, ignorance, or neglect, and not the result of an accident.

**Local Exposure** refers to exposure limited to a small area of skin or mucous membrane.
Systemic Exposure: refers to an exposure of the whole body or system, through adsorption, ingestion, or inhalation.

5.3.3 Types of Effects

Acute Effects refers to the duration of the symptoms, typically lasting a few hours or days. Again, it has nothing to do with the severity of the effects.

Chronic Effects are long-term effects, manifested by prolonged duration and continuing injury.

Local Effects occur in a small area, typically localized to the place of contact.

Systemic Effects occur throughout the body or away from the point of contact.

Allergies and Hypersensitivity are reactions to a chemical agent by particular individuals to particular chemicals. Often allergies and hypersensitivities are caused by heredity or prior overexposure. Individuals with these reactions should limit exposure to the offending agents.

5.3.4 Exposure Levels

Threshold Limit Value (TLV):
The TLV is the average level a person can be exposed to a chemical for 8 hours a day, 5 days a week forever, without adverse health effects. These levels are set by ACGIH (American Conference of Governmental and Industrial Hygienists), and adopted into law by OSHA (Occupational Safety and Health Administration). The TLV is most relevant to chronic (long term) exposure to chemicals in the work place. Short-term exposures in excess of TLV are not necessarily hazardous.

Immediately Dangerous to Life and Health (IDLH):
The IDLH level represents the maximum value for which a 30-minute exposure will result in no irreversible or escape impairing effects. The IDLH is the maximum level that will not cause irreversible organ damage or render you unconscious. It is the value most appropriate to sudden, one time accidental exposures. For your information, a short table of values for relevant chemicals is listed below.

IDLH
Ammonia: 500 ppm
Carbon Monoxide: 1500 ppm
Chlorine: 25 ppm
Hydrogen Fluoride: 20 ppm
Diborane: 40 ppm
Phosphine: 200 ppm
Short Term Exposure Limit (STEL):
The STEL is the maximum concentration to which you can be exposed for 15 minutes, up to 4 times a day without adverse health effects.

Permissible Exposure Limit (PEL):
The PEL is the statutory equivalent of TLV.

Lethal Dose 50% (LD50):
The LD50 is the dose at which 50% of exposed individuals will die. Separate levels apply to various modes of exposure such as inhalation, dermal absorption, etc. LD50 is often expressed in terms of mg per kg of body weight. Because these levels are generally determined using mice and rats as models they are approximate and have considerable variation. It is therefore wise to be conservative in estimates using these numbers.

5.3.5 Toxic Effects

- **Carcinogen**: A substance producing or inciting cancerous growth.
- **Mutagen**: A substance capable of inducing genetic mutations.
- **Teratogen**: A substance causing damage or death to a fetus.

5.4 Bringing New Chemicals into the Laboratory

Only specifically authorized chemicals may be used in the laboratory. Not every chemical or material is allowed in the laboratory such as cyanide and beryllium powder. Most standard processing chemicals have been pre-authorized; Materials Safety Data Sheets for these are available in the yellow binders at the entrance to the cleanroom. No other chemicals may be brought into the facility without prior authorization.

Users who want to bring a chemical into the laboratory that is not already pre-approved (i.e., already in the MSDS binder) must submit two copies of the MSDS sheet to laboratory management for review. Approval of new chemicals is not guaranteed and may take some time for staff to address issues such as chemical compatibility, waste disposal, and other issues. Researchers should refrain from purchasing chemicals until approval is granted.

If your chemical is approved for use in the laboratory the laboratory staff will show you where to properly store the bottle in one of the chemical cabinets in the laboratory. When storing chemicals in the laboratory users must label the bottle with the following information:

- Professor or Company Name
- User name
- Date the chemical was brought into the laboratory.
There is a six-month time limit for chemical storage. After six months, as indicated on the label, the Nanolab staff may remove the chemical and dispose of it. If you would like to keep a chemical for more than six months, simply write a new date on the label.

5.5 Toxic and Corrosive Gases

The Nanoelectronics Research Facility (NRF) located on the 1st floor of the ENG IV building uses small quantities of pyrophoric and toxic gases. The following section covers some properties of the major hazardous gases used in the facility. This list is not necessarily exhaustive but is meant to cover the major gases and the major hazards present in the facility.

5.5.1 Silane

Silane (SiH₄) is used for the deposition of polysilicon, silicon nitride, and silicon dioxide in the LPCVD and PECVD systems. Silane is pyrophoric, meaning it will spontaneously ignite in air or water vapor at concentrations between 2% and approximately 90%. It produces a white powder (glass) as a byproduct of its burning which is non-toxic. The silane gas cylinder is located in the toxic gas bunker.

5.5.2 Chlorine and BCl₂

Chlorine and BCl₂ gases are used in one of the etching systems. They are greenish-yellow in color and are strong oxidizers with a choking odor. Chlorine is in a double contained tube (tube within a tube) because of its toxicity. Chlorine forms HCl acid in the lungs, causing severe tissue damage, which can be fatal. As with many other corrosive gases, the effects of exposure may not be noticed for a few days. In all cases, medical attention should be sought immediately following exposure, not at the onset of symptoms. For your reference the following values relate to chlorine exposure.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLV</td>
<td>1 ppm</td>
</tr>
<tr>
<td>Odor Threshold</td>
<td>0.1 ppm</td>
</tr>
<tr>
<td>Coughing</td>
<td>30 ppm</td>
</tr>
<tr>
<td>Dangerous in 30 min</td>
<td>40-60 ppm</td>
</tr>
<tr>
<td>Fatal with a few breaths</td>
<td>1000 ppm</td>
</tr>
</tbody>
</table>

Because of the small amounts used, the ventilation used, and the low odor threshold for chlorine exposure, accidental chlorine gas exposure is not considered a significant risk.
5.5.3 Anhydrous Ammonia

Ammonia is used in the LPCVD and PECVD areas. Anhydrous Ammonia (NH₃) is a severely corrosive alkaline vapor with a pungent odor. Ammonia is flammable in the 15-28% concentration range. Ammonia exhibits good warning properties, with an odor threshold of 50 ppm. Although the TLV is only 25 ppm, concentrations up to 300 ppm can be tolerated for an hour. Concentrations above 3000 ppm are suffocating, causing convulsive coughing and respiratory spasm. Such exposures can rapidly be fatal.

5.5.4 Liquid Nitrogen

Nitrogen is considered a dangerous gas as more people die of asphyxiation by nitrogen than by any of the “toxic” gases discussed here. Liquid nitrogen is used for many things in the laboratory. A large liquid storage tank is located between Boelter Hall and Engineering IV.

5.6 Highly Toxic Gases

Several highly toxic gases are used in the silicon processing areas of the facility. These are limited to dilute diborane (0.2% B₂H₆ in nitrogen) and dilute phosphine (2 % PH₃ in nitrogen). Extreme care must be exercised with these gases, as exposure to small amounts can be fatal. Odor provides a poor warning for these gases as they are toxic at levels near or below the odor threshold. Because of the extensive safety precautions taken, no accidental fatalities have been reported in the semiconductor industry using these gases.

5.6.1 Phosphine

Phosphine gas is a severe pulmonary irritant and an acute systemic poison. Overexposure can cause either sudden or delayed death due to lung destruction. It is a colorless gas that is slightly heavier than air. Phosphine has a fishy odor, but is highly toxic at levels near the odor threshold so it must be treated with great care. The OSHA standard PEL (permissible exposure limit) is 0.3 ppm averaged over an 8-hour shift. Exposures of 1000 ppm for a few minutes are lethal. Phosphine can be tolerated for 30 min at 50 ppm (IDLH level). The odor threshold or phosphine is near 1 ppm. The phosphine used in the facility is mixed with silane so that a leak will burn rather than poison.

5.6.2 Dichlorosilane (H₂SiCl₂):

Dichlorosilane is a toxic, corrosive, flammable, water-reactive, colorless, gas. Dichlorosilane has an acidic, irritating odor. Dichlorosilane reacts with water, forming hydrogen chloride and hydrochloric acid. Exposure of Dichlorosilane with the skin, eyes, membranes, and other tissues can cause severe HCl burns. This gas is extremely
flammable, and releases of Dichlorosilane will usually ignite upon contact with air or water. It is considerably heavier than air.

5.7 Toxic Gas Monitoring and Control System

The gases used within the facility for processing are generally supplied under high pressure from compressed gas cylinders. These gases are stored in small steel cylinders in the toxic gas bunker located between Boelter Hall and Engineering IV (GS 130). This special bunker is built to handle small leaks and fires and was specially designed to accommodate the toxic gases used in the Nanolab. The bunker is kept locked at all times and may only be entered by trained personnel.

The gases are piped into the Nanolab in specially welded steel tubes that have been helium leak checked and are connected directly to various tools in the cleanroom. Gas sensors are strategically located to sense the smallest leak. Under a high alarm condition, the sensors shut off the gas, sound a building alarm and automatically call the fire department. Refer to Section 8 for more information regarding emergency evacuations.

Below is a list of the safety precautions that have been implemented for toxic gases.

- Gases are stored in an exhausted specially-designed bunker separated from the interior of the building.
- Orbital-welded stainless steel tubing
- An integrated gas detection system capable of sensing extremely small amounts of each gas. If a gas leak is detected, an alarm is activated and a fire dispatch signal is sent automatically.
- Excess flow sensors to shut the gas bottle down in the event of a leak.
- A seismic sensor to shut down all gas cabinets in the event of a major seismic event.
- Small quantities of each gas to limit the possibility of exposure.

5.8 Specific Chemical Hazards

Here is an overview of some specific or unique hazards from some chemicals commonly used throughout the facility. Users should review the MSDS for these and any other materials they work with.

5.8.1 Acetone and Flammable Solvents

Acetone is widely used throughout the facility. It is a very flammable solvent with a low flash point, (i.e. it can be ignited at a low ambient temperature). Because of this it is a
significant fire hazard. A spilled gallon bottle of acetone could cause a catastrophic fire or explosion. Solvents should also be handled with care in the hoods and are not to be used near hot plates as spilled solvents can be ignited by hot plates. Spilled solvents can also react explosively with chemical oxidizers such as peroxides and acids. Spilled solvents should be contained immediately with spill control pillows.

5.8.2 Hydrofluoric Acid

Hydrofluoric Acid (HF), a weak acid, is a very hazardous chemical, much more so than any of the other acids. Nanolab users must obtain special training before using HF. Its danger comes from its destructive effect on the tissues of the body. At many concentrations used in the laboratory, an HF “burn” is initially painless. The person may not even know that they have gotten a splatter on their hands, arms, face, or on their gloves. The delayed sensory reaction of the body to HF exposure is one of the main dangers of the acid. Considerable damage can occur before the person is aware of the exposure and mitigates it.

Upon exposure, the HF acid causes considerable tissue damage as it works its way through the skin and into deeper tissues. While penetrating the skin the fluoride ion is not consumed and becomes soluble in tissue and penetrates deeper and deeper, until it comes to the bone. After HF has penetrated deeply it is too late to reverse the considerable tissue damage. At some point, it enters the bloodstream scavenging $\text{Ca}^{+2}$ ions, and alters the ionic chemistry of the nervous system. If left untreated, serious injury or death will result.

HF burns are a unique clinical entity. Dilute solutions penetrate deeply before dissociating, causing delayed injury and symptoms. Burns to the fingers and nail beds may leave the overlying nails intact. Severe burns are those following exposure to concentrated HF (50% or greater) to 1% or more body surface area, HF of any concentration to 5% or more body surface area, or inhalation of HF fumes from a 60% or stronger solution. The vast majority of cases involve only small areas of exposure, usually on the digits.

Tissue damage is caused by two mechanisms, a corrosive burn from the free hydrogen ions and a chemical burn from tissue penetration of the fluoride ions. Fluoride ions penetrate and form insoluble salts with calcium and magnesium. Soluble salts are also formed with other cations but dissociate rapidly, releasing the fluoride ion allowing further tissue destruction.

The time to onset of symptoms is related to the concentration of the HF:

- Solutions of 14.5% produce symptoms immediately.
- Solutions of 12% may take up to an hour.
• Solutions of 7% or less may take several hours before onset of symptoms, resulting in delayed presentation, deeper penetration of the undissociated HF, and a more severe burn.
• Concentrated solutions cause immediate pain and produce a surface burn similar to other common acids with erythema, blistering and necrosis.
• The pain is typically described as deep, burning, or throbbing and is often out of proportion to apparent skin involvement.

Physical:
• Weaker solutions penetrate before dissociating.
• Surface involvement in these cases is minimal and may even be absent.
• Three categories of appearance:
  o A white burn mark and/or erythema and pain
  o A white burn mark and/or erythema and pain, plus edema and blistering
  o Ocular burns present with severe pain.
• Inhalation burns may develop acute pulmonary edema.

Simple washing of an HF splash is not sufficient to prevent damage. It does not wash off, but rather penetrates the skin and will continue to do damage until medical attention specific to HF burns is given (including deep injections to neutralize the penetrated acid). Be sure that medical personnel know that it is an HF burn and know that it requires specific treatment different from a common acid burn.

The recommended first aid for HF exposure consists of the following steps:
1. Remove any contaminated clothing making sure not to create secondary exposure
2. Rinse the exposed area with copious amounts of water for 5 minutes
3. Recruit other users in the lab to help and notify laboratory management
4. Apply Calcium Gluconate gel, stored in all the first-aid, HF cabinets, and waste cabinets, liberally to the affected area. Reapply every 15 minutes. Wear gloves when applying the gel to prevent transfer of HF and secondary burns. If exposure is to the hand, Calcium Gluconate can be placed inside a clean glove to soak the affected area.
5. Seek medical attention. Take the HF burn summary posted next to the first aid kits to the hospital and make sure to inform the emergency room personnel that it is an HF burn and must be treated differently than other chemical burns.

HF etches silicon dioxide very well. Therefore, it also etches glass. It must not be kept in a glass bottle, used in a glass beaker or disposed in a glass waste bottle. HF, like all other chemicals, must only be used in the chemical hoods.
5.8.3 Piranha Etch and NanoStrip

Piranha etch is a common name applied to a heated mixture of Hydrogen Peroxide and Sulfuric Acid (typically 1:2 to 1:5). It is extremely aggressive toward organic materials (e.g., biological tissues and photoresist residue, equally). It also removes heavy metal contamination. It is commonly used in the semiconductor industry and this laboratory for wafer cleaning.

As with all $\text{H}_2\text{O}_2$ containing solutions, when disposing of Piranha it is important to use a waste bottle with a vented cap as the waste continues to react and decompose for a long period of time. This can build up pressure in an un-vented waste bottle causing it to burst. Piranha solutions should be allowed to cool to room temperature before pouring into a waste container. Also if the solution is very peroxide rich, one can make unstable compounds. NanoStrip is a commercial stabilized version of Piranha that the laboratory uses for aggressive mask cleaning.

5.8.4 Tetramethylammonium Hydroxide

Tetramethylammonium Hydroxide (TMAH) exists in several different forms in the Nanolab. The most common usage is in dilute (<4%) aqueous solutions for developing photoresists. These developers are often referred to by their brand names, so it can be hard to determine without the MSDS, which developers contain TMAH and which are based on other bases.

Some Nanolab users use concentrated TMAH in water (~40%) for selective etching of silicon. TMAH in this form is significantly more hazardous than the dilute solutions used in the lithography areas. In addition to the corrosiveness of the material, concentrated TMAH is also highly toxic. The increase in toxicity of concentrated TMAH is much more than the increase in concentration. It is important for users to treat the concentrated material with much more caution, and not view it as simply a more concentrated developer.

5.8.5 Chlorinated Solvents

Chlorinated solvents (chlorobenzene, trichloroethylene, and methylene chloride) are used in various resist processes. They are particularly bad for the human body, causing cancer, organ damage, etc. If possible these solvents should be avoided for example by using a special lift-off resist rather than chlorobenzene. They should not be mixed with normal solvents in waste bottles. Users must use separate waste bottles for chlorinated solvents. As with most solvents, they can be readily absorbed through the skin. Chlorinated solvents (e.g., Methylene Chloride and Chlorobenzene) do not rinse well from bottles and other glassware. To properly remove the solvent residue from the containers, the container should be thoroughly rinsed with Isopropanol, with the rinse going into the
Chlorinated Solvent waste bottle. The item should then be rinsed with water, which may go down the drain.

5.8.6 Glycol Ethers

Commercial photoresists and electron beam resists are dispersed in a variety of solvents. The composition of these mixtures is generally not disclosed on the bottle; you must look on the MSDS for it. One family of chemicals, the glycol ethers, is commonly used in photoresists, and have a variety of trade names, which are again all identical.

Most photoresists contain one or more glycol ether as solvents. The present solvent of choice is PGMEA (propylene glycol mono methyl ether acetate) also known as 1-Methoxy-2-propanol acetate. Members of this family of chemicals have been shown to be teratogenic and have other effects on reproduction in laboratory animals. A number of recent studies funded by IBM and others have found evidence that these chemicals can lead to miscarriage and other reproductive effects. To quote from the MSDS for AZ 2131 Thinner (2 Ethoxyethyl Acetate and N-Butyl Acetate)

“In studies with laboratory animals, 2-ethoxyethyl acetate caused birth defects, increased fetal death, delayed fetal development, caused blood effects, testicular damage and male infertility.” The liquid and vapor are eye and respiratory tract irritants and may cause kidney damage, narcosis, and paralysis (in simple terms, it damages your kidneys, eyes, lungs, and brains). Primary routes of exposure are inhalation, skin absorption, and skin and eye contact with vapors. N-butyl Acetate, the other component of this thinner, has a similar list of possible systemic effects. These experimental laboratory exposures were large amounts but nonetheless it is prudent to be careful with these solvents.

5.8.7 Peroxides

All peroxides are highly oxidizing materials. Considerable energy can be released in their reactions with common materials. Some peroxide compounds are unstable, and can explode. The Hydrogen Peroxide in the facility is over ten times more concentrated than the solution used in the medical field and has a high contact risk. Extreme care should be used in mixing solutions containing peroxides. Peroxides are incompatible with all forms of organic solvents and flammable materials.

Users should be careful when disposing of pure hydrogen peroxide solutions in waste bottles. Adding pure hydrogen peroxide to an ammonium hydroxide / hydrogen peroxide or hydrochloric acid / hydrogen peroxide waste bottle can lead to rapid heating and breakdown of the peroxide, which can result in the waste bottle being over pressurized and rupturing.
When disposing of peroxide solutions it is important to use a waste bottle with a vented cap as the waste continues to react and decompose for a long period of time. This can build up pressure in an un-vented waste bottle causing it to burst.

5.8.8 Pregnancy

Users who believe themselves to be pregnant should discuss laboratory use with the management as soon as possible. This need not severely restrict laboratory use but should nonetheless be discussed.

5.8.9 Asthma, Rashes, or Unexplained Symptoms

If after using the Nanolab you experience unexplained health effects such as difficulty breathing, asthma, rashes, or other symptoms that cannot be explained users should notify the Nanolab staff so that cause can be determined. If symptoms are severe, users should immediately seek medical attention and inform the medical personnel what chemicals and processes the user may have been exposed to.
Section 6
Using Wet Chemicals

Wet chemical processing is one of the most dangerous aspects of working in the Nanolab. The danger is not only derived from the strength and reactivity of the chemicals used, but also by the direct interaction that users have with the chemicals. The policies procedures laid out in this section are designed to keep users safe, even in the event of an accident. However, the procedures are only effective as long as they are routinely followed and implemented with common sense. Failure to follow chemical handling procedures is a serious violation of laboratory policy and can result in permanent expulsion from the laboratory.

6.1 Chemical Supplies

The facility supplies chemicals commonly required for processing in the facility. In order to preserve space in the chemical cabinets, users are discouraged from bringing in their own stocks of supplied chemicals. Working stocks of chemicals are kept in the chemical cabinets located near the fume hoods. When the working stock of a chemical is finished users are encouraged to resupply the chemical from the extra stock of chemicals in the chemical cabinets located in the room in the Southeast corner of the Nanolab. Users must not restock a chemical until all opened bottles in a cabinet are completely emptied. Do not use chemicals that have a label indicating they belong to another user, call the user first. Please refer to Section 5.4 for information on bringing new chemicals into the laboratory.

Chemical bottles carried from room to room or from isle to isle in the laboratory must be carried in a rubber chemical carrying bucket. Users carrying bottles within a single room or isle are not required to use a rubber chemical bucket. All chemical containers moved outside of a fume hood must be sealed with a screw top lid. Open containers or containers with unattached lids may not be carried around the lab, even if they only contain water.

Users must not open a new bottle until the old one is empty. When a chemical bottle is emptied, it must be properly taken care of before a fresh supply of chemical is retrieved.
Empty bottles are reused as waste bottles and should not be thrown away. The procedure of handling empty bottles is as follows:

1. Empty bottles should be triple rinsed by filling the bottle half full of water, attaching the top, shaking, emptying, and repeating two more times.
2. After triple rinsing, a triple rinse label should be placed over the chemical label to obscure the previous chemical contents.
3. Triple rinsed and labeled bottles should be placed on the racks used to store empty bottles.

Chemical bottles that contained chlorinated solvents like methylene chloride must also be rinsed with isopropanol to get rid of the residual material before being rinsed with water. Chemical bottles that contained a polymer solution (photoresists, spin-on glasses, etc) need to have the polymer material completely rinsed out of the container before it can be disposed. Users must determine the correct solvent to do this and into what waste bottle the solvent rinse should go into. In many cases, Acetone is not the correct solvent for this. Contact the staff responsible for that area of the laboratory for assistance in the proper solvent choice.

### 6.2 Chemical Fume Hoods

The Nanolab classifies the chemical fume hoods into two groups: general use hoods, and designated use hoods. There are three general use hoods located in the laboratory. General use hoods do not need any special training and can be used immediately after a user has completed the safety walkthrough. General use hoods can be used for processing with acids, bases, and solvents.

Before using any hood it is necessary to check the magnahelic gauge to ensure that the hood is properly venting. Care should be taken to ensure that incompatible chemicals are segregated in the hood and cannot come into contact.

Designated use hoods all require users to attend a training session specific to that hood. In general there are restrictions on the materials that can be used in designated use hoods. A list of designated use hoods and their functions can be found below:

**Yellow Room Solvent Hood** – The materials used in this hood are limited to work involving solvents and mild bases for typical lithographic processing. No strong acids or bases can be used in this hood.

**Yellow Room Acid Hood** – This hood is designated for using strong acids and solutions such as Piranha, HF, wet metal etchants. No large-scale solvent cleans may be used in this hood, only spot cleaning with squirt bottles is allowed.
Pre-furnace Clean Hood (PFC) – The PFC hood is only to be used to clean wafers that are to be further processed in the high temperature furnaces. Contamination of the PFC hood is a serious violation of laboratory policy. There are severe restrictions for what materials can be used in the PFC hood:

- No Metals
- No III-V or other compound semiconductors
- No Photoresists or other organics
- No Wafers contaminated with the above from previous processing steps, even it stripped.

Porous Silicon Hood – The porous silicon hood houses the porous silicon etch machine that uses large quantities of HF. Porous silicon etching is the only activity that can take place in this hood.

6.3 Personal Protective Equipment

Appropriate Personal Protective Equipment (PPE) must be worn at all times when pouring wet chemicals at a fume hood. If necessary, the PPE may be removed after pouring to enable more dexterous handling of samples. The PPE should not be worn except in the immediate area of the chemical hood. Wearing the PPE around the lab will lead to transferring chemical residues into non-chemical areas of the facility.

For most wet chemicals the following is the full complement of Personal Protective Equipment (PPE) that must be worn when pouring or in cases where a splash is possible.

- A Face Shield
- Chemical Apron,
- Thick Chemical Resistant Gloves (over the standard cleanroom gloves).

6.3.1 Chemicals Requiring Only a Face Shield

For some chemicals it is only necessary to wear a face shield when pouring them. For these chemicals it is sufficient to wear the white cleanroom gloves (nitrile) and a full face visor, it is not necessary to wear the thick chemical gloves or an apron. A definitive list of chemicals that require only a face shield can be found in Appendix E. **Chemicals not found in the list in Appendix E require the full complement of personal protective equipment (i.e., face shield, chemical apron, and thick chemical gloves).**

If you are working at a fumehood and pouring a chemical that requires the full complement of PPE you must move away from the hood or also be wearing the full complement of PPE
6.3.2 Apron

Chemical aprons have a ‘chemical side’ that should face out when wearing it. This is to prevent chemical residues from the apron from coming in contact with the wearer. The Nanolab supplies chemical aprons.

6.3.3 Face Shield

The face shield is to be worn whenever working in or near the hoods. Users should only handle the face shield from the top. Do not handle the face shield by the front as this can contaminate the clear portion of the shield, decreasing visibility. The Nanolab supplies face shields.

6.3.4 Chemical Gloves

The most common type of chemical gloves used in the laboratory are thick green nitrile gloves. The Nanolab does not supply chemical gloves and users are required to purchase their own. Users must consider what chemicals they are using and purchase gloves that are resistant. Chemical gloves are to be worn over the standard cleanroom gloves while working in the hood. Chemical gloves should not be used to handle items outside the hood because the chemical residues can spread to others who are not wearing PPE and they can be injured. Gloves should be rinsed in DI water and dried with a clean wipe after each use.

To prevent contamination, the gloves should be removed whenever handling items outside of the hood such as phones, notebooks, sample holders, keyboards etc. When putting on or removing the PPE, the nitrile gloves should be the last item put on and the first item removed, to prevent transferring any chemical residues to the face shield or apron straps.

6.4 Chemical Hood Procedures

When preparing to use a chemical fume hood, users should always perform a series of actions to ensure efficient and safe use of the hood. Users should first check the magnahelic gauge to ensure that the hood is venting. Then the user should gather together and label all of the necessary chemical containers they intend to use. The user should then put on a chemical apron, face shield, and gloves. Users should make sure there is adequate space. If other users are present, wait until space is adequate. The user can then place the necessary chemical containers in to an appropriate location in the hood. Only then should the user retrieve and pour chemicals.
6.4.1 Working with Chemicals

Users should be sure to understand the risks of all the materials they work with in the hoods. The MSDS can be used to understand the properties and hazards of these materials. Here are a few specific things to keep in mind when working in the hoods:

• Use care when pouring chemicals. Transferring chemicals is the most common time for spills and accidents. Funnels should be used whenever necessary to prevent spills.
• Users should plan out their work when they start working in the hood. Users should make certain that they don’t need to carry a wafer dripping with chemicals over the length of the hood to get to the sink to rinse it.
• Be sure to take time and be careful with the chemicals. Not only will this help in producing good research, but it will also make the process safer.
• Avoid distractions while working at the hood. Do not take or make phone calls, use MP3 players, or engage in distracting conversations with other users. Focus on the work that is being performed.

Do not overcrowd the hood by trying to have too many people work at the same time. The current user of the hood may request that others wait until he or she is finished. This should not be used to claim the use of a hood for an excessive period of time though, but should be used to make certain that the work is done safely.

From time to time users may drop a sample into a heat bath contained in a fume hood deck. When this occurs users should staff get help to retrieve the sample. Users should never put their hand, with or without a chemical glove, into a bath to retrieve a sample or wafer cassette even if the bath is cold.

6.4.2 Chemical Containers

The labware should be made of compatible material and just large enough to easily work with the samples to be processed. Containers that are too large for a sample will create excessive waste and should not be used. Disposal costs for chemicals are often much more than the original chemical costs, so users should try to minimize wasteful use of the chemicals.

Plastic, Teflon, or glass containers are acceptable for most chemicals. If the solution is to be heated, only a glass container can be used. If using a hydrofluoric acid containing solution, use a plastic or Teflon container. It is advised that all containers have covers on them. Aluminum foil should not be used as a cover for any solutions containing acids or bases.
6.4.3 Container Labels

All chemical containers are required to have labels on them that clearly identify the contents. Many solvents and caustics look the same as water, so everything, including water, must be clearly labeled. Rolls of general-purpose cleanroom tape are available throughout the laboratory to label chemical containers. Do not use cleanroom wipes to label containers as the two may become separated.

The label must be clearly printed with the following information:

- Full Chemical Name and Concentration
- User Name
- Date
- Time Started
- Time of Anticipated Finished
- Phone number if you are going to leave the cleanroom

If possible the label should be attached to the chemical container itself and not the container cover or in the hood in front of the chemical. All containers are required to be labeled regardless of whether the user is going to be present the entire time or not. The label should be present on the container before the chemical is poured.

6.4.4 24-Hour Rule

Chemicals should not be left in the hood for long periods. Given the number of people in the facility, there is not enough hood space to allow each researcher to have their chemicals left in the hood for more than 24 hours. Chemicals that are to be used frequently over a period of a day may be left for reuse to help reduce the amount of chemical waste generated. By the end of the day however, all chemicals should be disposed of and the container cleaned up.

Chemicals that are hot may be left overnight and allowed to cool, but an extra note indicating this should be placed on the container to show that it was not forgotten about. Substrates are allowed to soak overnight in chemicals if needed, but a note indicating this should be placed on the container, in addition to the standard container label.

Users that are going to leave a chemical container in the hood for later reuse or disposal must place the container toward the back of the hood to make room for others.

Chemical containers that are left over 24-hours or left without a label will be disposed of. If there is a sample inside of the container it will be disposed of also.
6.4.5 Hot Plates

Hot plates may seem like a simple piece of laboratory equipment, but they can be dangerous if used improperly. There are several Nanolab supplied dedicated hotplates located in the yellow room used exclusively for baking photoresist. In addition, users are allowed to setup their own hotplates in the general use hoods.

It is important that users actively check the material on the hotplate, using a thermocouple to monitor the solution temperature to make certain that the chemical is not heated to a dangerous temperature. This is especially important as the material is being heated up to the operating temperature, as small solution volumes can quickly heat up to a dangerous temperature. In no cases are users allowed to use thermometers containing mercury to check the temperature of a solution.

Only glass containers should be used on hotplates, no matter what temperature the material is being heated to.

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

Heating flammable solvents on hotplates is highly controlled due to the risk of a fire from the flammable vapors that will be generated. Users must get laboratory management approval for the heating of any flammable solvents.

6.4.6 Waste Disposal and Cleanup

Once a user is finished with chemicals in a hood, the chemicals should be disposed of in the appropriate waste bottle. See Section 7 for information on how to dispose of the chemical waste. All chemical containers should be thoroughly rinsed with water. Special rinsing procedures are necessary for any container that held chlorinated solvents (see Section 7). After rinsing, containers should be dried with clean wipes and stored in an appropriate location, not in the hood. The labware should not have any chemical residues or smells. Thoroughly rinse chemical gloves before drying and storing.

When you are finished using a hood do not leave any extra wipes, containers, hotplates, thermocouple readouts, gloves, etc. All items should be returned to their proper places and the hood left clean, dry, and empty for the next user. Drying the hood counter is an important step, as the next user will not know if the drops on the counter are water or a dangerous chemical.
6.5 Procedure for Point of Use Filtering of Photoresist

Filtering of photoresists should not be necessary if the material is properly stored and transported. Resist vendors have much better techniques for filtering than we do. When working with photoresists, always make sure the mouth of the resist bottle is clean before pouring. After pouring, clean the mouth of the bottle and tightly cap the bottle. Failure to do this allows resist to dry and crust so that upon reopening the bottle, the debris can fall back into the bottle. The cap should remain on the bottle at all times except during pouring to minimize resist exposure to air. Resistors need to be stored in approved solvent cabinet or the explosion-proof refrigerator.

If however, you need to filter the resist, you must follow this procedure:

1. Make sure you have thoroughly read the MSDS sheet for the resist you are using.
2. Resist is flammable. Make sure there is no heat source such as hot plates in the immediate vicinity.
3. Only perform this in the yellow room at an approved fume hood or at the spin coater.
4. In addition to the gown and gloves, approved safety glasses that cover your entire eyes (wrap-around) are required. Goggles are also acceptable.
5. If possible make sure no one else is working next to you. If they are, they must also be wearing full safety glasses or goggles.
6. Only locking type syringes may be used (e.g., luer-lock or equivalent) so that the filter and needle do not come loose under pressure. The filter and syringe must also be compatible with the resist that is being filtered.
7. Do NOT reuse filters as they become plugged when the resist dries. Dispose spent filters as hazardous waste. See staff to assist you for disposal if necessary.

6.6 Chemical Handling Rules

Common sense and engineering knowledge is used as a guide. There may be situations not covered by the following rules. Consult with lab management for any situation that is unclear. Do NOT proceed if you have any doubt about the correct procedure.

Use of HBr and HF requires special training and only authorized users may work with HBr at the designated location.

1. All chemicals must be poured at a working fume hood. Magnehelic gauges should be checked BEFORE pouring chemicals to insure adequate exhaust. Do NOT pour chemical if exhaust is inadequate.
2. Chemical-resistant gloves, face shields, and aprons must be worn when working with wet chemicals.
3. Only approved chemicals already listed in the MSDS book may be used in the laboratory. Laboratory management must approve new chemicals not already in use in lab. MSDS sheets must be obtained before bringing new chemicals into the lab.
4. MSDS sheets must be read and understood before working with a chemical. All warnings and procedures regarding storage, disposal, etc. must be followed.
5. Chemicals poured in open beakers must remain under a fume hood. Do NOT move them out of the fume hood.
6. Beakers must be labeled as to chemical name, user name, date and time started, date and time expected to finish, and phone number.
7. Do NOT heat highly flammable liquids such as acetone and alcohol.
8. Turn off hotplates when finished.
9. Use rubber or nalgene carriers when transporting chemicals through the laboratory. Do NOT carry a bottle without a carrier unless it is directly across from the fume hood being used. Use a plastic cart with containment lip if you are bringing chemicals in from another lab.
10. All chemicals must be stored in clearly marked, sealed containers of a material compatible with the chemical (e.g., do NOT use glass with HF). Markings must include: chemical name, professor and date chemical was brought into lab.
11. Do NOT move or dispose hot chemicals, let them cool first.
12. Chemicals must be stored in the appropriate cabinet except when in actual use. Acids must be stored in the acid cabinet, bases in the base cabinet and solvents in the solvent cabinet.
13. Waste chemicals must be stored in the chemical waste cabinet in clearly marked carboys or waste bottles. Do NOT overfill waste containers. Use funnels where necessary.
14. Chemicals must NOT be stored or left for appreciable amounts of time on the floor or tables and must be labeled as to chemical name and/or strength of mixture.
15. Chemicals must NOT be stored underneath fume hoods.
16. Strongly fuming chemicals such as HCL and Ammonium Hydroxide must be used only in the recessed hot pot areas of the fume hood so that lip exhaust helps contain odors.
17. If strong odors are present during chemical processing, stop, turn off hot plate, if on, call lab management and evacuate area. Do NOT continue processing if you smell fumes.
18. It is recommended that you have your own personal chemical-resistant gloves. Wash gloves in DI water and dry them after each use.
19. Triple rinse empty chemical bottles including cap and affix triple rinse label over chemical name. Date and initial it and place rinsed bottle on the empty bottle rack.
20. Chemical waste must be poured AT THE FUME HOOD into the appropriately labeled waste bottle. Allow the chemical to cool first and wear safety visor, apron, and special gloves. Wipe down outside of waste bottle with DI water and clean wipe.

21. Use only vented caps (a small hole is visible in the top) or a waste bottle with a pop out plug in the spout for hydroxide and peroxide solutions.

22. If chemical processing at a fume hood needs to continue in your absence, you MUST place the setup towards the back of the hood out of the way and label it (use clean tape) with: your name, chemical(s) used, time and date poured, your phone number, and when you will finish.

23. Report all spills or chemical exposure to lab management. For small spills, spill kits are located adjacent to the chemical waste cabinets.

24. Use appropriate fume hood (e.g., solvent hood for solvents, acid hood for acids).

25. Report unsafe conditions or safety violations by others to lab management.
Section 7
Hazardous Waste Handling

There are several different types of waste generated in the facility, much of which is hazardous waste that needs special handling. The most common hazardous waste generated by users is chemical waste. Other hazardous waste classes include broken glass, other sharp materials, III-V materials containing arsenic, batteries, etc.

7.1 Chemical Waste

All chemical waste in the Nanolab is collected and stored. **No chemicals can be poured down the drain, only water.** For most acids, bases, and solvents, after the chemical waste has been emptied from a container, the water used to rinse the chemical residue from the container can be poured down the drain. There are some exceptions to this rule, most notably containers containing photoresist or chlorinated solvents, which must first be rinsed with a solvent.

7.1.1 Waste Storage

There are two waste collection sites in the Nanolab, one in the white room and one in the yellow room. Each waste collection site has all the necessary materials to handle routine chemical waste tasks as well as materials for chemical spills. More information about how to handle spills can be found in Section 8. Materials found at the waste collection sites include:

- White polypro chemical cabinet for acid waste
- Steel chemical cabinet for base and solvent waste
- Racks to hold empty triple-rinsed bottles
- Blank chemical waste labels
- Vented caps
- Acid neutralization solution
- Base neutralization powder
- pH paper
- Spill pillows
- Spill bags
At the waste collection sites chemical waste is stored in sealed waste bottles. As with all chemical cabinets throughout the laboratory, chemical waste must be segregated by the type of waste. Each shelf in a cabinet should only contain one type of chemical (i.e., acids with acids, bases with bases, and solvents with solvents). There are labels on the shelves indicating what type of chemical belongs on the shelf. If you notice that a waste bottle is not being stored in the proper location, please move it to the correct location. If there is not enough room on a shelf, see if there is room at the other waste collection site. If there is no room in either location, contact laboratory management.

When disposing of chemical waste, users should find a waste container at the waste collection site and bring it to the fume hood that the user is working at. All chemical waste must be poured at a working fume hood. A funnel makes the task of transferring waste to a waste bottle with out spilling easier. Once the chemical waste has been transferred to the waste bottle it is important to ensure that any spills and drips are cleaned from the bottle and the bottle is dried. It is necessary to ensure that the bottle is completely dry before returning it to the waste collection site.

If there is no waste bottle that is compatible with your chemical waste or if all appropriate waste bottles are full, you will need to create a new waste bottle. The creation of a new waste bottle starts by retrieving an empty triple-rinsed one-gallon bottle from the empty bottle racks located at the waste collection sites. It is often a prudent practice to rinse the bottle one last time to ensure that there are not unwanted chemical reactions when waste is transferred to the bottle. Smaller bottles are also available for uncommon waste materials. See laboratory staff if you would like a small waste bottle or if there are no gallon bottles available.

A chemical waste tag then must be completed and attached to the chemical waste bottle before pouring your waste into the bottle. When attaching the waste tag to a triple-rinsed bottle, place it over the triple rinse sticker. An example of a blank waste tag is shown in Figure 1. It is important to note that you must use the full chemical name(s) and not formulas or abbreviations. If you have any questions about how to correctly label your chemical, please ask staff for assistance.
7.1.2 Vented Caps

All waste bottles that contain hydrogen peroxide (H₂O₂) must have a way to vent excess pressure. For gallon bottles there are special vented caps located at the waste collection sites. The vented caps allow for excess pressure generated from any chemical reactions in the bottle to safely escape the container. These will only slowly vent excess pressure, so it is important to minimize any secondary reactions in the waste bottle. Failure to use vented caps can result in a bottle exploding and seriously injuring people in the laboratory.

7.2 Chlorinated Solvent Waste

Chlorinated solvents (e.g., Methylene Chloride and Chlorobenzene) do not rinse well from bottles and other glassware. To properly remove the solvent residue from the containers, the container should be thoroughly rinsed with Isopropanol, with the rinse going into the Chlorinated Solvent waste bottle. Then the item should be rinsed with water, which may go down the drain.
7.1 Solvent Contaminated Items

Wipes, gloves, or other items that have resists or other spin on polymer solutions on them should not be disposed of in standard trashcans. These polymer solutions will release the solvents into the air. In the lithography room there is a special trashcan next to the spinners that are to be used for disposing of these items.

7.2 Sharp Items

Glass, wafers, razor blades, needles, or other sharp materials should not be disposed of in the standard trashcans, as it can cut the plastic trash bags and injure the janitorial staff. The facility has special sharps trashcans located behind the furnaces. The trashcans are labeled for the disposal of glass waste. Silicon wafers and pieces of wafers should also be disposed in this trash. Empty glass chemical containers should not be placed into these trashcans, but instead should be triple rinsed and placed on the empty chemical bottle racks located at the laboratory chemical waste collection sties.

7.3 Compound Semiconductor Waste

All waste pieces of Gallium Arsenide, Indium Phospide, and similar compound semiconductors should be deposited into the small-labeled bin located behind the furnaces. This is to prevent arsenic contamination of the normal trashcans.
Section 8
Emergency Procedures

There are many different types of emergencies that can happen in the laboratory. Although it is not possible to plan ahead for every type of possible emergency, the following sections cover the main types of emergencies that may occur with the appropriate response for each.

8.1 Using the Phones To Get Help

To access these emergency services from the regular Nanolab phones, dial 911. When calling in an emergency, it is important to clearly communicate the type of emergency to the dispatcher. For medical emergencies it can be helpful to clearly indicate whether the medical emergency is chemically related or not. For example, the emergency response for someone having a heart attack is different than for a person who has a chemical exposure.

Additionally, names and telephone numbers of responsible staff members are posted on the fire placards attached to the laboratory doors. Staff members should be contacted for emergencies such as large water leaks, power outages, and other serious problems.

8.2 Emergency Response Equipment

Emergency equipment is located throughout the laboratory. Users must familiarize themselves with the location and operation of emergency equipment. Spill control kits are located next to the chemical waste cabinets. Bottles of neutralization liquid and powder are located inside of all chemical cabinets. Emergency showers and eyewashes are located throughout the facility. There are two First Aid Kits available in the laboratory. Tubes of Calcium Gluconate Gel are available for application on hydrofluoric acid burns. This should be applied promptly, but is not a substitute for medical attention. There are fire extinguishers located in the laboratory.
8.3 Chemical Exposures

All chemical exposures require immediate attention. Users who are exposed to chemicals, must immediately remove all affected clothing as soon as possible to assist in getting the chemical off of the body. Modesty should not prevent users from doing this. Flush the affected areas with water for 15 minutes, not less. Use the emergency shower and/or eyewashes as necessary. Memorize the locations of the safety shower and eyewashes. If exposure occurs while working at a fume hood and the exposed area is small the DI water spray can be used to rinse the affected area. Users affected by chemical burns should not worry about any chemical spill, but instead should take care of themselves and allow someone else to deal with the spill. It is a good idea while rinsing the effected area to call for help from another member of the laboratory.

If your eyes are exposed to a chemical while working at a fume hood, if you can do so safely, use the DI water spray to flush your eyes instead of trying to make your way to an eyewash station. Hold your eyes open and flush continuously for 15 minutes. The DI water spray will be your fastest response for such an emergency when working at a fume hood. Exposure of the eyes requires flushing with water for at least 15 minutes. As a precaution, all exposures to the eye will require a visit to an emergency room for a check up. Contact a staff member as soon as possible for assistance or call 911.

After you have flushed the exposed area with water contact a staff member or have a labmate contact the staff while you are rinsing the effected area. All chemical exposures occurring in the Nanolab must be reported to the office within 24 hours or on the Monday following a weekend.

HF burns are particularly hazardous. An insidious aspect of HF burns is that there may not be any discomfort until long after exposure. These burns are extremely serious and may result in tissue damage as fluoride ions diffuse through tissue. If you are exposed to HF, flush the area well and be sure to work under and around your fingernails. Under fingernails and cuticles are the main areas people receive burns, having washed off the HF without washing under their nails. Remember, HF may not produce any burning sensation until after it has already done damage. You should have a physician examine all HF burns.

8.3.1 First aid for HF burns to skin:

1. Remove contaminated clothing.
2. Flush with cold water for 5 minutes.
3. Get help from other lab members of staff.
4. Gently massage a liberal amount of Calcium Gluconate Gel to the affected area. Calcium Gluconate Gel can be found at the first aid kits as well as on top of most chemical cabinets. Use gloves to avoid secondary exposure of fingers.
5. Report all HF exposures to staff
6. Seek medical attention

8.4 Chemical Spills

Users are primarily responsible for cleaning up any minor chemical spill they caused. For large spills users should request assistance from the staff or Environmental Health and Safety. Spill kits located at the chemical waste collection sites and contain various items such as spill pillows and wipes for soaking up larger spills. Acid and base neutralizers are located inside of chemical storage cabinets to assist in making the material safer to cleanup. In the event of a minor spill users should:

1. Wear personal protective equipment (apron, visor, and chemical gloves).
2. Turn off any hotplate or heat sources.
3. Neutralize the spill if spill contains acids or bases.
4. Contain the spill and soak up with spill pillows or wipes.
5. Place an appropriately filled out chemical waste label on the bag.
6. Place contaminated materials in to a chemical waste bag and seal the bag.
7. Treat the chemical waste bag as hazardous waste and store on the appropriate shelf in the chemical waste cabinets.
8. Notify staff of the spill.

For major chemical spills, spills releasing significant hazardous fumes, and for any unanticipated chemical reaction, users must evacuate the area or the laboratory and call Environmental Health and Safety. Any user may call for an evacuation of the laboratory at any time using the paging system. All users must honor evacuation requests and promptly evacuate the cleanroom. After evacuation remain near the laboratory entrance to inform the emergency responders of the location and type of material spilled.

8.5 Building Alarms

The facility has two types of audible alarms that evacuate the building: fire alarms and toxic gas alarms. For a Fire Alarm, sirens and strobe lights will go off throughout the laboratory. A siren followed by a message that a toxic gas emergency has occurred in the building indicates the toxic gas alarm. The response to both types of alarms is the same: users may take 10 seconds to secure whatever tool they may be working with before evacuating the facility. In addition, all requests from staff to evacuate the facility must be honored immediately. They should then calmly walk to the nearest exit of the facility and
meet at the front or West side of the building away from the toxic gas bunker on the east side of the building. Researchers in the cleanroom should not return to the growing room to remove the cleanroom suit, but instead, should exit out the nearest door, and remove the cleanroom suit when they reach safety. Users should not reenter the building until given the OK by the emergency personnel on the scene. All alarms should be treated as real. Occasional testing of the system is clearly announced throughout the building intercom system. If a user is ever in doubt about whether an alarm is real or not, they should proceed to evacuate, and then determine if the event was real once they have left the area.

In the event of an explosion, large fire, or other circumstance that requires the entire building to be evacuated, toxic gases to be shut off, and police and fire departments to be summoned, users should press one of the emergency evacuation buttons located in the facility. The exact location of the buttons will be shown during the walkthrough.

8.6 Fire

The Nanolab has three fire extinguishers located inside the laboratory. They are all 10 lb type A-B-C extinguishers. If a fire is discovered, alert other laboratory users and personnel and stand clear to assess the situation. Do NOT attempt to fight fires larger than "waste basket" size or fires obviously out of control. If you are not comfortable fighting the fire yourself, activate a fire alarm and evacuate the laboratory. If you are comfortable fighting the fire the procedure is outlined below.

1. Locate the nearest fire extinguisher and lift it off its wall support hook. Set it on the floor.
2. While firmly grasping the extinguisher's handle, briskly pull the locking pin, breaking the plastic tie.
3. Firmly grasp the nozzle handle and point toward base of fire.
4. Move to within ten feet from fire's base and squeeze handle, thereby releasing extinguisher's contents toward base of fire.
5. Continue extinguishing fire by using a sweeping pattern across the base of the fire until the fire is out.
6. Once fire is out, alert others to all-clear condition, and initiate secondary clean-up of broken glass, beakers, dry chemical powder, etc.
7. Alert Laboratory Management to condition of laboratory as a result of the fire and the sequence of events (if known) leading up to discovery of the fire.
8. If you are unable to extinguish the fire activate a fire alarm and evacuate the building.
8.7 Earthquakes

If you are in the cleanroom during an earthquake, duck under the nearest sturdy object and hold onto it until the shaking stops. If you are not near a sturdy object, make yourself as small as possible and cover your head and neck. If you stand in a doorway, brace yourself against the frame and watch out for a swinging door or other obstructions.

Avoid windows, fume hoods, chemical cabinets, process equipment, storage cabinets, and other heavy or dangerous objects that could fall or shatter. Stay under cover until the shaking stops, then evacuate the building. If safe, before evacuating, stabilize any laboratory procedure that could lead to further danger. Do not reenter the building until you receive definite information from the laboratory management that the building is safe.

8.8 Incident Reporting

In addition to normal emergency response, all accidents involving chemicals and all accidents involving personal injury must be reported to the facility management in writing as soon as possible after the incident. Explanations should include the nature of the event, the procedures being followed or not followed at the time, and actions required to prevent future similar incidents. In addition, for cases involving personal injury to employees, the university may require additional documentation.
## Revision History

<table>
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<tr>
<th>Rev No.</th>
<th>Date</th>
<th>Section, Page &amp; Paragraph</th>
<th>Author</th>
<th>Brief Description Change</th>
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<tr>
<td>7.0</td>
<td>1993</td>
<td></td>
<td>Markus Van Loan</td>
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<td>7.1</td>
<td>1/8/1999</td>
<td></td>
<td>Steve Franz</td>
<td>Revision</td>
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<td>8.0</td>
<td>1/1/2009</td>
<td></td>
<td>Brian Matthews</td>
<td>Complete Rewrite</td>
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<tr>
<td>8.1</td>
<td>3/6/2009</td>
<td>6.3</td>
<td>Brian Matthews</td>
<td>Modified PPE requirements. Added Teir I and Teir II classes in Appendix</td>
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<td>8.2</td>
<td>12/28/09</td>
<td>6.5, Appendix A</td>
<td>Brian Matthews</td>
<td>Fix typos, add Syringe Filtering Section, Updated Telephone List, Removed references to badge deposit, inserted updated New User Application</td>
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<td>8.2.1</td>
<td>2/5/10</td>
<td>6.4.1</td>
<td>Brian Matthews</td>
<td>Added warning about retrieving samples from a heated bath</td>
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Acknowledgements

Thanks to the many UCLA faculty and graduate students who have participated in the making of this laboratory and helped debug many of the equipment and processes. The collective individual contributions both small and large have made this laboratory successful and useful to a wide range of researchers and disciplines.

Much of this work was adapted from other laboratory manuals from across the country. In particular much inspiration, information, descriptions, and organization came from the 10th edition of the Cornell Nanoscale Science and Technology Facility Laboratory Usage and Safety Manual (http://www.cnfusers.cornell.edu/doc/CNF_Lab_Manual_10th_edition.pdf). Other sources include the laboratory manuals from BSAC at Berkeley, Georgia Tech, and Stanford. Many thanks to these institutions for their excellent documents.
Appendix A: New User Application
NANOELECTRONIC RESEARCH FACILITY
NEW USER APPLICATION

Part 1: User Information (to be filled out by the Professor, PI, or Supervisor)
Thank you for your interest in using UCLA's Nanoelectronics Research Facility. We ask you to carefully read and fill out the following form. It is also important that all requested dates be filled in and that this form be signed by the professor, PI, or supervisor. By submitting this form you confirm that the researcher named below needs access to the Nanoelectronics Research Facility for the time duration stated below as part of his/her research activity. By submitting this form you also acknowledge below that your work at UCLA is of a research or prototyping nature that requires special capabilities found at UCLA. For laboratory users claiming the internal rate, you agree that your use of the facility and equipment is solely for the purpose of UCLA's academic and research interests. Violators may be barred from using the facility and School of Engineering employees will be subject to discipline. If the status of the researcher changes for any reason, you must notify the Laboratory Management of the change.

Please note: There is a minimum monthly charge per academic researcher or per company until the account is canceled. (Please refer to the current rate sheet for the minimum monthly charge).

☐ I do not authorize the $25 startup fee to be charged to my account and want the researcher to pay.

Researcher Name: ___________________________ E-Mail Address: ___________________________

Supervisor Name: ___________________________ Institution: ___________________________

Recharge ID (UC researchers) or PO# (non-UC researchers): ___________________________

Start and End Date for Nanolab Usage
Start Date: _________________ End Date: __________________

Professor, PI, or Supervisor Signature: ___________________________ Date: _________________

Part 2: User Acknowledgement (to be signed by the researcher performing the work in the NRF)
I acknowledge that I have read and understood the NRF Lab Usage guide and the Orientation Presentation and have gone through UCLA's walkthrough orientation for safety and chemical handling procedures. I am aware of the hazardous materials and equipment in the laboratory and I agree to follow all UCLA NRF's safety and operating procedures.

Researcher Name: ___________________________

Researcher Signature: ___________________________ Date: _________________

Part 3: Indemnification Clause (for non-UCLA researchers only)
UCLA shall defend, indemnify and hold (company name: __________________________) (henceforth called the user institution), its officers, employees and agents harmless from and against any and all liability, loss, expense (including reasonable attorneys' fees) or claims for injury or damages arising out of the performance of this agreement but only in proportion to and to the extent such liability, loss, expense, attorneys' fees, or claims for injury or damages are caused by or result from the negligent or intentional acts or omissions of UCLA, its officers, agents, or employees.

The user institution shall defend, indemnify and hold UCLA its officers, employees and agents harmless from and against any and all liability, loss, expense, (reasonable attorneys' fees) or claims for injury or damages arising out of the performance of this Agreement but only in proportion to and to the extent such liability, loss, expense, attorneys' fees, or claims for injury or damages are caused by or result from the negligent or intentional acts or omissions of the user institution its officers, agents, or employees.

Manager or Supervisor Signature: ___________________________ Date: _________________

User Signature: ___________________________ Date: _________________

For Nanolab Use ONLY:
Walkthru by: ________ Walkthru date: __________ Badge #: ______ Rate: __________

Rev. 1/2010
Appendix B: User Action Form

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See Next Page for Form
**Nanoelectronics Research Facility (NRF) User Action Form**

<table>
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<tr>
<th>Last Name:</th>
<th>First Name:</th>
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<tbody>
<tr>
<td>Badge #:</td>
<td>UID #:</td>
</tr>
<tr>
<td>PI:</td>
<td>Department:</td>
</tr>
</tbody>
</table>

**Action request (Date: _______________):**

- [ ] Suspend user (minimum of 4 months absence)
- [ ] Reactivate user (advance 1 week notice)
- [ ] Terminate user (return badge to Mr. Steve Franz)
- [ ] Unsubscribe to Nanoall mailing list:

  (Correct email address to be removed.)

**For PI and/or account number change(s):**

- Previous PI: ____________________
- New PI: ____________________
- New account number: ____________________

**For badge refund:**

(Please provide a mailing address to send check. If you have direct deposit, refund will be deposited to your bank account.)

- Street address:
- City: ____________________
- State: ____________________
- Zip code: ____________________

**Authorizing Signature (PI):**

- Print Name Above: ____________________
- Date: ____________________

**Instructions:**

1. Print out and complete this form.
2. Obtain required Authorizing Signature.
3. Submit to: Jamie Jung
   Nanoelectronics Research Facility
   Rm 56-125EE or Rm 14-131A, Engr. IV Bldg.

Office Use Only

<table>
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<tr>
<th>Badge</th>
<th>Refund</th>
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Date ____________________

(Rev 08/2005)
Appendix C: Nanolab Phone List

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See Next Page for List
# User Laboratory Telephone Numbers

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<tr>
<th>Name</th>
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<tr>
<td>Fire, Police, Ambulance</td>
<td>x911</td>
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<tr>
<td>Hazardous Material Spills</td>
<td>x55689</td>
</tr>
<tr>
<td>Nanolab</td>
<td>x69597</td>
</tr>
<tr>
<td>Microlab</td>
<td>x66706</td>
</tr>
<tr>
<td>CNSI Cleanroom</td>
<td>x33331</td>
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<tr>
<td>Do, Hyunh</td>
<td>x64641</td>
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<tr>
<td>Fan, Yuwei</td>
<td>x65528</td>
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<tr>
<td>Franz, Steve</td>
<td>x68923</td>
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<tr>
<td>Jung, Jamie</td>
<td>x69908</td>
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<tr>
<td>Lee, Tom</td>
<td>x64641</td>
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<tr>
<td>Lin, Wilson</td>
<td>x68923</td>
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<tr>
<td>Malek, Ghassan (CNSI)</td>
<td>x33179</td>
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<tr>
<td>Matthews, Brian (CNSI)</td>
<td>x33255</td>
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<td>Ngo, Hoc</td>
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<tr>
<td>Trang, Jacquelyn (EE Dept. MSO)</td>
<td>x59094</td>
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<tr>
<td>Tokunaga, Lorna (Nanolab/CNSI)</td>
<td>x55357/x33413</td>
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<td>Zendejas, Joe</td>
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<tr>
<td>Zhu, Minji (Microlab, Hybrid Lab)</td>
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# Internal Laboratory Extensions

## Nanolab Extensions
(Use Intercom button)
- Furnace Aisles: x236
- Metals/Dry Etch Aisles: x237
- Gown Room: x238
- Yellow Room: x239
- Leica Room: x240
- NanoLab Office: x233

## Microlab Extensions
(Use Intercom button)
- Microlab Office-Grant: x230
- Lecture/Testing Room: x231
- Lab Gowning Room: x232
- Lab Processing Room: x234
- Photolithography Room: x235

For after hours staff support, please call x65528

Rev 1/1/10
Appendix D: Chemicals Supplied by Nanolab

D.1 Solvents

- Isopropanol ([CH\textsubscript{3}]\textsubscript{2}CHOH)
- Methanol (CH\textsubscript{3}OH)
- Acetone (C\textsubscript{3}H\textsubscript{6}O)
- Aleg 355 stripper

D.2 Acids

- Hydrochloric Acid (HCl)
- Sulphuric Acid (H\textsubscript{2}SO\textsubscript{4})
- Hydroflouric Acid (HF)
- Nitric Acid (HNO\textsubscript{3})
- Buffered Oxide Etch 6:1 (HF: NH\textsubscript{4}OH)
- Hydrogen Bromide (HBr)
- Acetic Acid (CH\textsubscript{3}COOH)
- Phosphoric Acid (H\textsubscript{3}PO\textsubscript{4})

D.3 Bases

- Potassium Hydroxide (KOH)
- Ammonium Fluoride (NH\textsubscript{4}OH)

D.4 Etching Solutions

- Chromium Etchant (CR-7S)
- Gold Etchant

D.5 Photolithography Chemicals

- AZ5214E IR Photoresist
- AZ 4620 Photoresist
- SU-8 2100 Photoresist (user pays for amount used)
- PMMA A4 Photoresist
- AZ Developer
• AZ 300 MIF Developer
• AZ 400K Developer
• SU-8 Developer
• AZ 1500 Thinner
• AZ 300T Stripper

D.6 Evaporation Sources

• Titanium (Ti)
• Chromium (Cr)
• Aluminum (Al)
• Copper (Cu)
• Gold (Au, user pays for amount used)
• Platinum (Pt, user pays for amount used)

D.7 Sputter Sources

• Titanium
• Chromium
• Aluminum
• Copper
• Nickel

D.8 Miscellaneous

• Hexamethyldisilazane (HMDS)
• Hydrogen Peroxide (H₂O₂)
Appendix E: Chemicals Requiring Only a Face Shield

Chemicals not found in this list the full complement of personal protective equipment (i.e., face shield, chemical apron, and thick chemical gloves).

E.1 Solvents

- Isopropanol ([CH₃]₂CHOH)
- Methanol (CH₃OH)
- Acetone (C₃H₆O)

E.2 Photolithography Chemicals

- AZ5214E IR Photoresist
- AZ 4620 Photoresist
- PMMA A4 Photoresist
- AZ Developer
- AZ 300 MIF Developer
- AZ 400K Developer