

Laboratory Usage And Safety Manual for NSTLC

**Nanoscale Science and Technology Laboratory Clean Room
Oak Ridge National Laboratory
Oak Ridge, TN 37831**

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Laboratory Usage and Safety Manual for NSTLC

1.0 Policy and Procedure Summary

NSTLC Safety Policy

It is the responsibility of all users and staff to act in a professional, courteous, and safe manner while in the facility. Users violating the operating and safety rules of the facility or endangering the safety of themselves or others will be denied further access.

Who to contact in case of an emergency

Laboratory Shift Supervisor 574-6606
Gary Alley: 574-5725 or 376-3734 (after hours)

The required attire for working in the clean room is:

Hood with face mask

Coverall

Booties

Nitrile Cleanroom gloves

Dress-in procedures are posted in the vestibule.

Keep all hair and ears covered with hood. Bouffant caps are available for users with long hair.

Never open your gown in the cleanroom.

Only authorized users may enter the cleanroom unescorted.

The buddy system must ALWAYS be used in the cleanroom. NO EXCEPTIONS!

Visitors must be escorted by a cleanroom qualified staff member.

No food or drink is permitted in the cleanroom.

No corrugated cardboard, styrofoam, foam rubber or non-cleanroom paper is permitted in the cleanroom.

No pencils, erasers, or retractable pens are permitted in the cleanroom.

Be considerate of other users. Properly label all chemicals you are using and clean up afterwards.

Ask for permission before bringing anything in or taking anything out of the cleanroom. This is especially important for chemicals.

If you have not been trained on a piece of equipment, you are not permitted to use it. NO EXCEPTIONS.

DO NOT modify or change anything on the equipment without the approval of the tool's owner.

IF YOU AREN'T SURE HOW SOMETHING WORKS, ASK BEFORE YOU USE IT!

2.0 Scope

This document is a reference manual covering the basic operational policies for use of the facilities in the Nanoscale Science and Technology Laboratory Clean Room (NSTLC) located in Building 3500 on the campus of Oak Ridge National Laboratory (ORNL). It applies equally to all users, and governs both safety and clean room rules. All users must read and understand these procedures.

The clean room is a multi-user facility which poses significant hazards if not handled properly. Rules and general safety policies outlined in this manual should be followed; however there is no substitute for **common sense**. Anyone who fails to act in a professional, safe, and responsible manner while working in the NSTLC will be denied access to the facility.

User's suggestions and feedback on the facility, its staff, its operation, and its equipment are welcome at all times. Please feel free to direct your suggestions to any NSTLC staff member.

3.0 General Procedures in Accessing NSTLC

3.1 Access

The NSTLC is located in Building 3500, Room 8. The facility is for the exclusive use of those affiliated with and working on a facility approved research project. Use of the facility by any individual is a privilege that can be revoked by the facility management at any time.

3.2 Obtaining Access to NSTLC

The procedure for obtaining access to the clean room is posted on the NSTLC website: <http://www.ornl.gov/nstl/index.htm> in the area labeled user information. Access to the NSTLC is granted by a request to ORNL security to re-program the proximity reader on the clean room to allow entry using your badge. At the time of the request the applicants UT/Battelle badge number will be electronically checked against the NSTLC training requirements which are posted on the website. If the required training has not been completed access will be denied. NSTLC training is a combination of web based and personal training and must be retaken whenever significant changes are made to the facility.

The NSTLC is a badge in and badge out facility. Failure to badge out when leaving the facility will automatically trigger the reader to deny access the next time the user attempts to badge in. In order to regain access to the facility the user must be badged in by a staff member then scan his or her badge through the exit reader, which will reset the reader and allow access. Please note that it is very important to badge out as billing cycles are calculated this way, see Section 3.8, User Communication and Billing.

3.3 New User Orientation

Orientation to the clean room is required in addition to the web-based training. Orientation will be conducted by an NSTLC staff member and will consist of a facility tour, pointing out safety procedures, emergency exits, alarms, and any hazards present that may not have been covered in the web-based training.

3.4 User Areas

Users are only permitted in the vestibule, change room, and clean room areas. Users are not permitted in the service chase area except for emergency exit from the clean room. Access to the service chase area is limited to NSTLC staff members and maintenance personnel accompanied by a staff member. Room 9 is considered a service chase area and is thus restricted.

3.5 Clean Room Vestibule and Gowning Area

No unnecessary items such as coats, backpacks, etc. should be taken into the clean room vestibule or gowning areas. There is a gowning procedure posted in the vestibule. **Follow it!** Use the shoe cleaner located in the vestibule before entering the gowning area.

3.6 Clean Room Log In

The badge reader on the door tracks entry into the clean room. Users are charged for time spent in the clean room, that is elapsed time between badge in and badge out. This makes badging out of the facility upon leaving very critical. Charges will be billed in one half-hour increments. In addition, the stepper located in the photolithography room has a separate charge which is added to the overall billing. The current billing rates will be posted on the NSTLC bulletin board located in the hallway outside the clean room, or can be obtained by calling Kathy Martin at 576-4837. These fees are used to cover operational costs of the facility.

3.7 Hours of Operation

Except for special circumstances (cleaning, instrument maintenance, tool change out, etc.) the clean room will be open day and night seven days a week. When the facility is to be closed, advance notice will be given. Use of certain instruments and procedures may be limited to normal working days, i.e., 7:00 a.m. to 6:00 p.m. Monday through Friday. We employ the buddy system at NSTLC. A buddy is another knowledgeable user within the facility such as a staff member, who can and will watch out for you in case of trouble. You may not wet etch, mix chemicals, or dispose of chemical waste without another user in the area. In addition, some tools may have sign in and safety procedures to address specific safety requirements for their use. These requirements will be posted at the tool.

3.8 User Communication and Billing

All users must supply Kathy Martin with an e-mail address. The NSTLC website (<http://www.ornl.gov/nstl/index.htm>) will be the primary mechanism for user notification of equipment and clean room status. Users must also supply a valid charge number before performing any work in the cleanroom. Billing will occur at the end of each business month.

3.9 NSTLC Safety Review

The clean room will undergo a quarterly safety self-assessment by division Environmental, Safety, Health, & Quality (ESH&Q) staff. They will review equipment installations and operating procedures. All users are encouraged to report any safety concerns or suggestions to an NSTLC staff member.

4.0 Equipment Use and Availability

4.1 Approved Users

Access to the clean room does not of itself permit use of any particular tool. Each major instrument is under the charge of a staff member “tool owner.” The owner is responsible for training users on that particular instrument. When the owner is satisfied that the user is competent to operate the instrument, he or she will be authorized to use it without supervision. A list of authorized users for each tool will be posted on the bulletin board in the hall outside the clean room. Each tool owner’s name and contact information will be posted there as well. If you wish to be trained on a particular tool, arrangements must be made with the owner. Training is done at the owner’s convenience. Any use of a tool by an untrained person is specifically prohibited and is grounds for expulsion from the facility. If you feel a tool is not functioning properly, contact the owner or a staff member.

Do not attempt to repair any tool yourself!

4.2 Equipment Scheduling

NSTLC equipment is reserved through a web-based system, accessible via the NSTLC website (<http://www.ornl.gov/nstl/index.htm>). You must have an ORNL computer account to make reservations on the system. Depending on the instrument and demand, the amount of time you may reserve in advance may be limited. Unneeded reservations should be cancelled at the earliest possible time. If you fail to cancel your reserved time less than one hour before you are scheduled to use the equipment, your account will be charged for the period of time you had reserved the equipment for. All projects require a process flow between instruments, and delays are inevitable. We encourage you to be flexible and cooperative with others in stretching, sharing, and relinquishing time slots.

5.0 Clean Room Policies

5.1 Contamination Control

The primary sources of pollutants in a clean room are people. Your clothes, your feet, your skin, and your hair produce particulates, which can compromise research goals.

- Do not bring anything into the clean room that is not absolutely necessary for the work you are doing.
- Do not wear make-up
- Do not comb your hair in the clean room or gowning area
- Bare legs must be covered.
- Do not use pencils or erasers in the clean room
- No outside coats are permitted in the clean room
- Unpack boxes outside the clean room
- Only clean room paper and clean room notebooks are allowed
- Clean off equipment, parts, tools, etc., before bringing them into the clean room
- No food, drink, or gum
- No pets are allowed in the clean room

If you are not sure if an article can be brought into the clean room, ask a staff member. Remember it is your research that is at risk.

5.2 Safety Glasses

Safety glasses with side shields must be worn in the NSTLC clean room at all times. Safety glasses for visitor use are available and located in the dispenser at the entrance to the clean room. These glasses are not to be worn by regular users. Safety glasses may be removed for short periods of time in order to operate optical

microscopes. Eye and face protection for chemical handling will be addressed in Appendix B, Chemical Safety.

5.3 Clean Room Apparel

We gown in full “bunny suits.” That is with coveralls, hoods, mask, boots, and gloves. When you enter the gowning area take a set of clean room apparel and don it per the posted instructions. When your session in the clean room is finished, re-enter the gowning area and remove your clean room clothing, placing the coverall and hood in the gowning cabinet, the boots in the rack, and throw away your gloves. If you have been assigned a Tyvek garment, please write your name on the coverall before placing it in the gowning cabinet. Apparel for the clean room is changed out once per week. We ask that those assigned to cloth garments place their week-old coveralls, hood and boots in the designated bin for laundering. Tyvek garments will be disposed of weekly so users dressing in Tyvek should simply open a new set for use during the week’s use.

5.4 Clean Room Airflow and Cleanliness levels

The NSTLC is divided into three areas: the Photolithographic area at the north end of the clean room is a class 100 area, that is a count of fewer than 100 particles larger than .5 microns per cubic foot of air; the Metrology & Materials Processing area in the center of the clean room, a class 1000 area; and the Wet Etch & Film Growth area, class 100, located at the south end of the facility. Airflows to each of these areas must be balanced in order to maintain these levels of cleanliness. Do not prop open doors or place equipment up against the vents in the room, as this will disturb the flow of air that is carrying contaminants from the room.

5.5 Visitors

Users are not allowed to take casual visitors for tours of the clean room. Most of the facility can be viewed from the windows in the hallway and the vestibule area. More in depth tours can be arranged for researchers or individuals planning on having project work done in the facility. You are responsible for the actions and safety of your guests. Group tours (four or more) are disruptive to ongoing research and should be approved and scheduled in advance by the facility manager.

5.6 Phones

There are three phones in the clean room and one in the vestibule area. They are as follows:

Wet Etch & Film Growth - 576-2727

Metrology & Material Processing - 576-2720

Photolithographic - 576-2732

Vestibule - 576-2718

These phones are for business use only. If a personal call needs to be made please keep it brief, as these phones serve as a communication link from the vestibule area to the clean room proper.

6.0 Clean Room Service Area

The double doors on the north and south end of the clean room lead to the facility service area. These doors can be used as emergency exits from the clean room if necessary. These doors cannot be opened from the service area. **Users should never open these doors unless there is an emergency or are instructed to do so by a staff member.** The service area is accessible to staff members and maintenance personnel from the hallway doors. Anyone entering this area should exercise extreme caution, as there are many hazards present. There is low piping, trip hazards, and numerous pumps, chillers, and other ancillary equipment located throughout the area. Laser-based smoke beam detectors are located above the clean room vents and in close proximity to the outside walls of the clean room. Breaking these beam paths by placing equipment in front of them or by standing in front of them for any length of time will summon the ORNL Fire Department. A momentary intrusion into the beam will not activate the alarm, but even this should be avoided.

7.0 Personal Chemical Safety

Safety is the overriding concern at the NSTLC. All operations must be undertaken with this idea in mind. Anyone violating safety rules or compromising their safety or the safety of others will be denied access to the facility. Suspensions from the facility are at the sole discretion of the facility management and can range from a few days to permanent revocation of access. There is no excuse for unsafe behavior! Safety concerns can be reported to any staff member, division safety officer, or line management.

7.1 Chemical Safety

Rules on chemical safety are formulated on basic chemical knowledge, properties of individual chemicals, and common sense. The primary source of information on any chemical can be found on the Material Safety Data Sheet (MSDS). MSDS sheets for chemicals present in the NSTLC are organized in a folder located in the gowning area. No chemical may be introduced into the facility without approval of the NSTLC staff and the filing of the related MSDS and Hazardous Material Inventory System (HMIS) paperwork.

7.2 Chemical Do's and Don't's

Common sense is the most valuable aid you have in working with chemicals. If you are unsure, either don't do it or ask one of the managers or staff. It is impossible to enumerate all the rules and cautions applicable to chemical use, but there are a few to consider:

- Always add acid to water.
- Perform all chemical operations carefully. Moving, mixing, pouring.
- 24 hours maximum parking of "cooling" beakers in hoods. Empty them as soon as possible.
- Chemicals must remain under the hoods. Move them around inside, not outside.

- Keep your head above the bottom of the Plexiglas guard, especially when mixing, pouring, and heating.
- Don't leave gloves lying around – store them or pitch them.
- Don't sit down at the hood; it puts your face directly in the vapor path.
- Finish open chemical bottles before opening new ones.
- Put the correct caps on waste bottles. There are at least two different kinds - vented and unvented.
- Don't use blowguns near open chemicals.
- Don't use chemicals in shallow sloppy containers.
- Don't use plastic beakers on hot plates. (Yes, people have done this!)

Clean up after yourself and be careful.

7.3 Chemical Handling

In order to make the clean room a safer place to work we require that some basic rules for handling chemicals be followed.

- All containers (beakers, dishes, etc.) being used for “chemistry in process” must be labeled before you use them. Post-it notes are available at all hoods for this process. The label should include your name, the chemical name, and the date. Some pieces of labware are permanently labeled and are to only be used for the chemical/process specified.
- It is the users responsibility to properly dispose of unneeded chemicals and stow chemicals for later use. Waste and unneeded chemicals are to be poured in properly labeled waste containers and the approximate amounts are to be recorded in the waste chemical log associated with that container.

- Chemical storage cabinets are available in the facility. Unlabeled chemicals will be confiscated.
- Chemicals must be approved and cannot be used until the MSDS is read and understood.
- Waste containers must be used properly and not overfilled.
- Specialized gloves, face shields, and aprons are required when handling chemicals in the wet processing hood.
- When handling chemicals, outside distractions should be avoided (phone, visiting, etc.).
- Empty chemical bottles should be filled and rinsed three times with water before disposal.

7.4 Lab Ware

Glassware and plastic ware are available in the facility. After use, all lab ware should be emptied, rinsed three times with water, and left upside down next to the sink. Please help to keep the processing areas tidy by placing clean glassware in the storage shelves and carts located near each hood.

7.5 Hood Operation

The hoods in this facility are laminar flow hoods. The airflow is such that when improperly used they can vent fumes into the room. Work well back into the hood.

All chemical operations are to be done within the hoods. There currently is one hood in the wet etch and film growth area of the facility used for acid and base processing and there is one hood in the lithography area which is for solvent use. Do not use solvents in the acid or base hood or vice versa. Hoods must be clean, neat, and dry before and after each use.

7.6 Hot Plates

Hot plates used for heating chemicals must be attended at all times. You must be in the clean room and near the hot plate whenever it is plugged in. You may not heat solvents with flashpoints of <130°F. The acid and base hoods are extremely flammable, so nothing that could pose any kind of a fire hazard is permitted. No mercury thermometers are allowed in the facility.

7.7 Chemical Storage

All chemicals when not in use should be stored in the chemical cabinets located in the clean room. The hoods are not to be used for storage. Because of our limited chemical storage space, you should not expect to keep personal chemicals in the facility. You may not store custom solutions in the facility without prior staff approval. All special chemicals and solutions must be labeled with the owners name, contents, and the date they were introduced into storage. The facility stocks the chemicals commonly required for processing. These stocks are kept in Room 9. The staff is responsible for replenishing clean room supplies when necessary. Chemicals must be transported in the rubber chemical buckets kept next to the chemical storage cabinets.

Thoroughly rinse and wash empty chemical bottles. Empty bottles should be uncapped and placed on the disposal cart located in the cleanroom. Some chemical bottles must be rinsed with a solvent to rid the bottle of residue and odor. Do not place chemical bottles in the regular trash receptacles.

7.8 Protective Equipment for Chemical Handling

An apron, face shield, goggles, and gloves are provided at the acid/base workstation. When working in the acid or base hoods, you are required to wear a chemical apron, chemical gloves and a full

face shield. It is also recommended that goggles be worn under the full facemask. When working in the solvent hood, safety glasses (or preferably goggles) and chemically resistant gloves are required. The clean room gloves are primarily intended to protect your samples from fingerprints, they will not keep chemicals from your skin. The following rules apply for the chemically resistant gloves.

- Check gloves for holes
- Wash gloves when contaminated
- Wash gloves before removal
- Wear gloves to open chemical cabinets
- Wash and remove gloves before handling other objects in the room

The protective clothing is for use at the chemical hoods only. Available are full length gauntlets for arm protection and a full length apron. They must be worn when working in the acid and base hoods and must be removed when using other equipment in the facility.

7.9 Pregnancy

Pregnant users, or anyone who believes themselves to be pregnant, should discuss facility use with the Safety Officer as soon as possible.

7.10 Buddy System

The buddy system applies to the use of wet chemicals before, during, and after normal working hours. This essentially requires that you have a knowledgeable user be in the clean room, aware of your situation, and close enough to lend assistance should you require help anytime you perform wet chemical processing. The single

exception to this rule is the use of standard lithography chemicals, which applies only to common resists, developers, and solvents.

7.11 Spill Control

Please see Appendix A for the NSTLC procedure and policy on handling spills within the facility.

7.12 Chemicals Found in the Clean Room

- **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 presents a significant fire hazard. A spill of a gallon bottle of acetone could cause a catastrophic fire or explosion.

It should not be transported except in chemical buckets. Solvents should also be handled with care in the hoods and not used near hot plates. Spilled solvent can be ignited by the hot plates. The resulting fire could easily be drawn up into the exhaust ducts, again with catastrophic consequences. Spilled solvents can react explosively with chemical oxidizers present, e.g., peroxides, nitric acid. Spilled solvents should be contained immediately with spill control pillows. The Laboratory Shift Superintendent (LSS) should be called for emergency response and to assist in clean up.

- **Hydrofluoric Acid**

Hydrofluoric acid (HF) presents a significant hazard for personal injury. It is used in the lab in its diluted form, and as the active component of Buffered Oxide Etch (BOE). It is used for etching silicon dioxide, and particularly for stripping the native oxide prior to further processing. HF, however, is a very hazardous chemical, much more so than any of the other acids. Its danger comes from its effect on flesh.

At the concentrations used in the clean room, an HF “burn” is initially painless. You may not even know that you have gotten a splatter on your hands, arms, face, or in your gloves. The acid, however, will silently eat away at your flesh. The fluoride ion is not consumed in this process and is soluble in tissue, so the damage penetrates deeper and deeper, until it comes to the bone. About this time the excruciating pain begins. It is too late, however, to reverse the considerable tissue damage. At some point, it enters your blood stream and goes everywhere scavenging Ca ions, totally messing up the ionic chemistry of your nervous system. **At some point, if left untreated, you die.**

Simple washing of an HF splash is not sufficient to prevent damage. It does not wash off, it is already dissolving you and will continue to do so until you receive **medical attention specific to HF burns** (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.**

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. Plastic lab ware is available for this purpose.

HF, like all other chemicals, must only be used in the acid chemical hood. **It is not acceptable to take a beaker of acid into the process area to strip a sample just prior to loading in a vacuum system.**

8.0 Toxic Gas Alarms

Gas Safety is addressed in Appendix B.

8.1 Toxic Gas Alarms

The cleanroom is equipped with monitoring devices for all of the toxic gases used within the facility. Any release of these **toxic gases** would trigger an audible toxic gas alarm. The appropriate response to this alarm is to shut off any equipment you may be using and evacuate the cleanroom immediately using any of the emergency exits. The occupants of Building 3500 should also be alerted to such an emergency by using the pull box (located near the ends of the hallway outside the cleanroom facility) indicating that steps should be taken to evacuate the building.

Appendix A - Chemical Spill Response

A.1 Introduction

These spill response procedures were created to familiarize the cleanroom user with certain spill response actions. There are many potentially dangerous chemicals in the clean room and the possibility of a major spill always exists. It is necessary to know how to react quickly and properly to any chemical spill to avoid injury, death or major equipment damage. A large acid spill might cause serious injury or even death if handled improperly. These procedures are intended only to provide a guideline and common sense should always be used when dealing with a chemical spill. Safe practices should be foremost on your mind whenever handling chemicals in the clean room.

Small spills of nonflammable chemicals should not require evacuation of the building, unless excessive fumes are generated. You are primarily responsible for cleaning up any **minor** chemical spill you cause, using safe and approved procedures. **You should request assistance from staff for any significant spill which you cannot handle.** Do not dispose of contaminated rags or broken chemically laden glass in the normal waste baskets. You should rinse the waste articles, bag them, label the bag, leave the bag in a ventilated hood, and seek assistance from a staff member on further disposal.

For **major chemical spills** and any unanticipated chemical reaction, you must evacuate the clean room area immediately; call the NTSLC Laboratory Director or Manager, and the LSS. You must remain available to provide information regarding the spill. Any user may call for an evacuation of the clean room area at any time. All users must honor these “requests” until such time as the situation is evaluated.

In addition to normal emergency response, all accidents involving chemicals and all accidents involving personal injury must be reported to the NTSLC Laboratory Director, Laboratory Manager, and Safety Officer. Explanations should include the nature of the event, the procedures being followed or not followed at the time of the accident, and action required to prevent future similar incidents. If accidental chemical exposures occur or if signs and symptoms of chemical exposure are noted, report to medical for evaluation.

A.2 Spill Response

Materials used to control a chemical spill are located near the hoods on the East wall of the clean room. Spill control pillows are available for absorbing liquid chemical spills. There is an emergency shower and eye wash station located in the center portion of the clean room. A wet-dry vacuum is available for picking up powdered residue from neutralized chemical spills. The vacuum is located in Room 7. It should be rinsed after each use.

A.3 What to Do if *You* Spill Something

Most cases will involve a small spill of a known chemical you are working with.

Some basic guidelines are:

- *Did the chemical spill on you?* Remove all contaminated clothing and rinse area for a minimum of 15 minutes.
- Alert other users in the area to the situation.
- For acids and bases, obtain the proper neutralizing agent which is found near the east wall of the wet processing area.
- For small spills (1L or less) use absorbent pillows located in the wet processing area to soak up the chemical.
- For larger spills, use absorbent pillows in conjunction with chemical dams to prevent excessive flow of the chemical throughout the clean room.

- If the chemical is an acid or base, wait for the neutralizing reaction to finish before soaking up the chemical.
- Place soaked material in one of the trash bags found near the spill kit and then place this bag inside another, effectively double bagging the absorbent material. Label the bag with its contents, i.e. the chemical absorbed.
- Alert staff to have the bag disposed of properly.

If the spill is highly reactive or if you do not feel you can properly contain the spill, evacuate the clean room (alerting other users as well) and immediately phone the laboratory shift supervisor (574-6606) and request that a chemical response team be sent to the clean room.

A.4 What to Do if *You Find* Something Spilled

Treat all unidentified chemical spills as extremely dangerous. Assess the situation; if the chemical is reacting and/or releasing a strong odor, alert others and evacuate the clean room immediately, otherwise contact a staff member or the Laboratory Manager about the situation. If you can identify the chemical, i.e., see the spilled bottle and can read its label and if you feel you can handle the spill, proceed with the cleanup as outlined in the previous section.

Appendix B - Gas Safety

The gases used within the facility for processing are generally supplied under high pressure from steel compressed gas cylinders. In most cases, these cylinders are housed in special gas cabinets and fitted with a variety of high purity valves, regulators, and flow control devices. Many of these gases are toxic, or at least severely corrosive. Since odor is not a reliable detector for these gases, the NSTLC has installed a sophisticated toxic gas monitoring system. The system is designed such that any leak is exhausted directly, minimizing the amount that can enter the working area.

Improper use of gas cylinders and valves can result in contaminated gas and ruined samples and equipment. Compressed gas equipment in the facility is not user serviceable. Gas bottles are to be changed only by the appropriate staff members.

B.1 Hazardous Gases Used

Ammonia (NH₃): A colorless, strongly alkaline and extremely soluble gas with a characteristic strong, pungent odor. Reacts with silane in a CVD process to form silicon nitride (Si₃N₄).

Argon (Ar): An inert gas used as a plasma source in sputtering equipment.

Boron Trichloride (BCl₃): A colorless, fuming liquid or gas with a pungent odor. Reacts rapidly with water to form boric and hydrochloric acids. Used as a p-type dopant and etchant gas in certain reactive ion etching processes.

Chlorine (Cl₂): A corrosive gas with a strong unpleasant odor. The gas is used in the reactive ion etching system. TLV = 0.5 ppm, odor threshold = 0.1 ppm.

Freon 14 (CF₄): An inert gas used in plasma etching.

Freon 23 (CHF₃): An inert gas used in plasma etching.

Hydrogen (H₂): An extremely flammable, colorless, odorless gas. Used in the reactive ion etching system.

Nitrogen (N₂): A colorless, odorless gas used to purge process chambers.

Oxygen (O₂): A colorless, odorless gas that supports combustion. Used for wet and dry growth of silicon dioxide in a furnace and for plasma ashing of photoresist.

Silane (SiH₄): An extremely flammable (pyrophoric) gas with an unpleasant odor. Ignites with air in concentrations down to 1%. Used in CVD deposition of epitaxial and polycrystalline silicon and silicon nitride. TLV = 5 ppm.

Sulphur Hexafluoride (SF₆): A gas used in plasma etching.
TLV = 1000ppm.

Anhydrous Ammonia (NH₃): A severely corrosive alkaline vapor with a pungent odor. It is used in image reversal processes. TLV = 25 ppm and has an odor threshold of 50 ppm, concentrations up to 300 ppm can be tolerated for an hour.

Appendix C - Acronyms

Ar – Argon

BCl₃ – Boron Trichloride

BOE – Buffered Oxide Etch

CHF₃ – Freon 23

CHF₄ – Freon 14

Cl₂ – Chlorine

CVD – Chemical Vapor Deposition

ESH&Q – Environmental, Science, Health, & Quality

ESTD – Engineering Science & Technology Division

HF – Hydrofluoric Acid

H₂ – Hydrogen

H₂O₂ – Hydrogen Peroxide

HMIS – Hazardous Material Inventory System

IDLH – Immediately Dangerous to Life and Health

LSS – Laboratory Shift Superintendent's Office

MSDS – Material Safety Data Sheet

NH₃ – Anhydrous Ammonia

N₂ - Nitrogen

NSTLC – Nanoscale Science and Technology Laboratory Clean Room

O₂ - Oxygen

OSHA – Occupational Safety and Health Administration

ORNL – Oak Ridge National Laboratory

PEL – Permissible Exposure Limit

ppm – Parts per million

ppb – Parts per billion

Si₃N₄ – Silicon Nitride

SiH₄ – Silane

SF₆ – Sulphur Hexafluoride

STEL – Short-Term Exposure Limit

TLV – Threshold Limit Value

TLV-TWA – Threshold Limit Value – Time Weighted Average

TWA – Time Weighted Average

Appendix D - NTSLC Staff

Special Responsibilities

Director	Gary Alley
Facility Use Coordinator.....	Richard Kasica
Division Safety Officer.....	Cathy Wilson
Cleanroom Safety Coordinator	Richard Kasica
Waste Chemical Coordinator	Darrell Thomas
Building Supervisor	Frank Kolski
Clean Room Systems	Darrell Thomas
Laboratory Supplies	Darrell Thomas
Toxic Gas Systems	Darrell Thomas
Room Log In	Kathy Martin