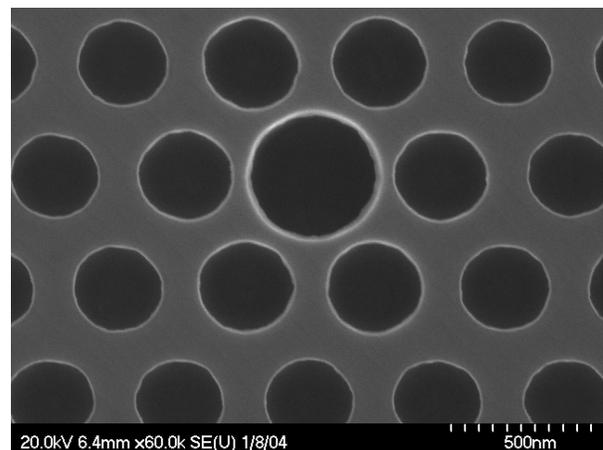
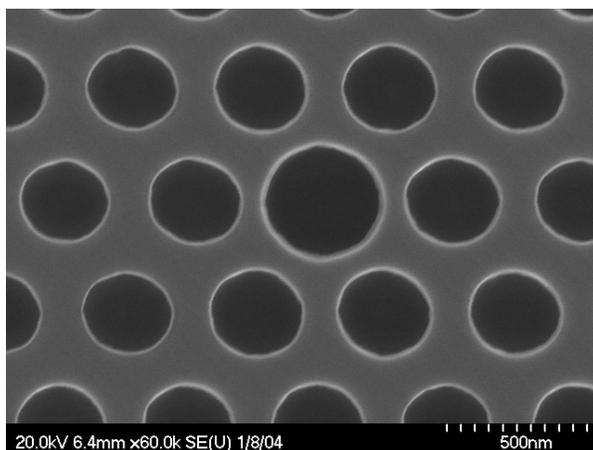
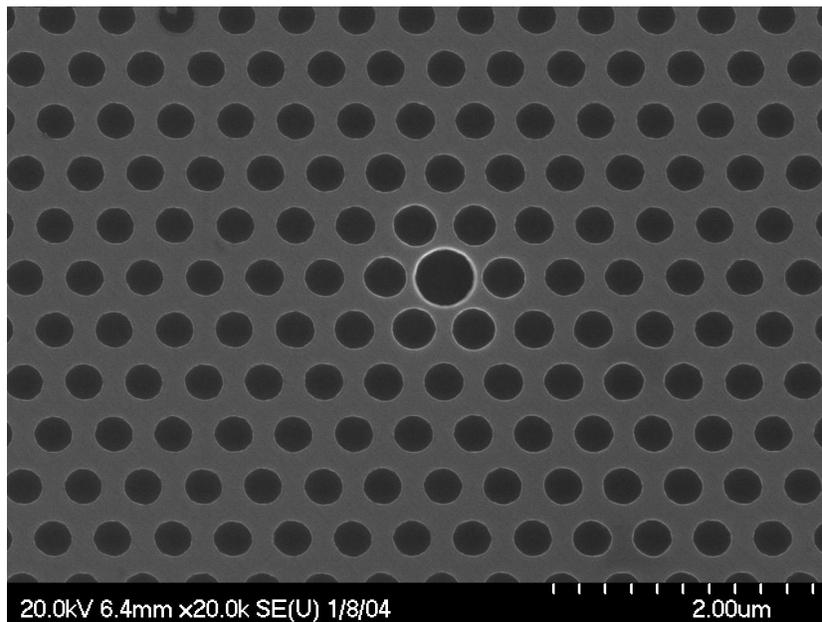




AMPEL Nanofabrication Facility Members' Laboratory Guide

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Free-standing 2D photonic crystal membrane with a defect cavity. Fabricated by electron beam lithography in the AMPEL Nanofabrication Facility by M. McCutcheon (J. Young group).

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Introduction

Mission Statement of the AMPEL Nanofabrication Facility

To provide expertise, thorough training and access to a reliable suite of micro/nano fabrication processes and characterization in a cleanroom environment.

General

In this handout are guidelines to assist members working in the AMPEL Nanofabrication Facility (a.k.a. AMPEL cleanroom). The objectives of this handout are:

- To orient new members to the cleanroom in terms of the facilities available and their locations in the lab.
- To familiarize members with the honor system reporting procedure that runs the lab; and
- To review the safety and cleanroom policies that must be observed at all times when working in this class-1000 and 10000 facility. Certain points of etiquette will also be mentioned.

It is imperative that you maintain an awareness of safety and cleanroom policies whenever you are in the lab. This will keep the lab as contaminant-free as possible, and more importantly, a safe place where staff and students can work.

Since this handout is meant to accompany the lab tour, the first section is organized according to the order in which we will visit the various rooms. Procedural and safety matters will be discussed as they pertain to each area, and a brief mention of safety equipment and machinery will be made. The next section will discuss log-sheet usage, and finally, an overview of cleanroom procedures for contamination control will be presented.

Access

The rules to access the cleanroom and its equipment are fairly simple. They are designed first to ensure everyone's safety and, second, to ensure that equipment get properly used. The Nanofabrication Laboratory's mission is research: use of the facility for industrial R&D is encouraged but production work, including pilot production, is discouraged. The access rules are summarized as follows for different categories of users:

- UBC faculty, research staff, and graduate students are allowed preferential access after completion of:
 - The UBC Chemical and Laboratory Safety Orientation Course or its equivalent (evidence required);
 - The orientation course and;
 - Qualification on individual equipment, including the wetbench (see Qualification point below);
- UBC undergraduate, exchange, summer or other temporary students are allowed access when sponsored by a UBC faculty member:
 - Undergraduate students on temporary part-time projects are to be chaperoned by a qualified user at all times (eg Undergraduate project courses);
 - Undergraduate students on longer term projects, such as summer projects, need to fulfill the same requirements as graduate students;
 - Exchange undergraduate students are to be chaperoned by a qualified user at all times;
 - Exchange graduate students need to fulfill the same requirements as UBC graduate students.
- Non-UBC users who do not benefit from direct supervision or collaboration with a UBC faculty member may also be granted cleanroom access after agreement with the cleanroom manager. This category of users include:
 - Students from other universities;
 - Research staff/students from government labs or other public institutions;
 - R&D professional staff working in industry;

- non-UBC users are required to satisfy the same, or equivalent, chemical and lab safety course requirements as are UBC users and;
 - non-UBC users still need to follow the orientation course and get qualified on individual equipment (even if they are more experienced than our superusers).
- One time, or infrequent, users are welcomed as visitors and may observe while a qualified user performs the work they have requested.

Qualification on individual equipment proceeds as follows:

- Completion of training with a qualified* user
- Qualification by a superuser;
- The user and superuser fill in, sign and date the qualification form (Appendix I).

Safety: The Buddy System

Always remember that, in principle, no one should work alone in the lab for obvious safety reasons. Since the AMPEL cleanroom is so small however, this rule will not be strictly enforced immediately. However, the spirit of this idea should be respected, especially when working with chemicals. Use the BUDDY SYSTEM. During normal hours, when working with chemicals, always make sure that someone knows where you are and will check on you periodically. It is ***strongly recommended*** that people work in pairs when using the cleanroom for chemistry (wetbench) outside of the normal working hours. When in the cleanroom outside of normal working hours for less dangerous use (SEM, microscope, evaporators, etc.), make sure that someone else is present in the building (advise this person when you leave the cleanroom).

Fees

The AMPEL Nanofabrication Facility is subsidized by an overall government grant (ie public money) to UBC. The access and fee based system reflects this: preferential treatment is given to UBC and other public institutions while the facility is also made available to the general community. The guidelines for these fees are revisited and approved periodically by the Nanofabrication Facility Management Committee. They are as follow:

- UBC Faculty are guaranteed the lowest access fees (no other user can pay less);
- Users from other Canadian public institutions (universities, government labs, etc.), or institutions providing public services, such as hospitals, are charged a small extra premium which is negotiated on an individual basis;
- Industrial users from small or startup Canadian companies may be offered advantageous fees, depending on the social and economic benefits of their R&D programs, that are negotiated on an individual basis;
- All other users will be able, on an individual basis, to negotiate usage fees that reflect the philosophy and bias expressed in the preceding bullets.

Reception Area

Login Policy

A table with the login binder is found just outside the entrance door. The binder contains an up-to-date users list and login sheets. Only members whose names are on the list are allowed unchaperoned access; anyone else needs to be chaperoned by a qualified user. The cleanroom is locked nights and weekends: qualified users wishing to use the cleanroom outside of normal working hours (9:00-18:00 M-F) can request a room key.

Login is required each time you enter the lab. This keeps accounting records and monitors your time in the lab. Also, your login allows others to see that you are in the lab so that you can be notified for any reason (emergency, visitor, etc.). Do not forget to log out when you leave the lab and to record your equipment time usage as well as how many consumables you used.

Please be aware that safety always comes first. The above policy will be reviewed periodically and new restrictions may come in effect in the future

Phone Policy

Two telephones are installed in the cleanroom (one in each room). The phone number is 2-1653. Please restrict your use of these lines for cleanroom related work only as 1.) it is extremely annoying to answer other people's personal phone calls and 2.) it may cause another user to miss a legitimate equipment service call.

Visitors

If you wish to bring visitors into the lab, you must get permission by contacting the lab manager (Mario, 2-1853 beaudoin@physics.ubc.ca). If you obtain approval, be sure to log your visitors in under the "Visitor" category as soon as you enter the lab. Please refrain from bringing visitors in on weekends!

Gowning Area

Storing Gowns

Behind the reception area is the monitoring area (where you see the chart recorders). Beyond the monitoring area is the gowning area, which is where lab member and visitor lab wear is stored. This is where you will "gown up". When you are ready to begin work in the lab, obtain a plastic coverall storage box (available in the gowning area; please record it on the login sheet) in which to store your bunny suit, cap and beard cover. To avoid soiling your other garments, you will need to keep a set of shoes and booties in the stainless steel gowning bench shelves. Identify these with your name and the date. Visitor's garments are clearly marked and are hanging on the rack along the right wall of the gowning area. Visitor's booties are found on top of the hanging rack. Shoes are to be removed in the monitoring area OUTSIDE of the gowning area. Bags and coats are to be left in the monitoring area where there is an external rack. Users proceed into the gowning room and thoroughly clean their socks or feet on the tacky mats.

Please note that, though they are disposable, all garments should be used until they are torn or soiled. Shoe covers should not be discarded until the soles are torn. They should be checked each time you put them on. These garments are expensive and should not be thrown away until they are no longer usable. Note that these items are consumables that are charged to your thesis advisors.

Storing Shoes

In accordance with Workers Compensation Board (WCB) and UBC regulations, all users must have proper foot protection in the lab. It is recommended that a pair of covered shoes or sneakers (no sandals or open toe footwear) be thoroughly washed and cleaned, covered with booties and stored permanently in the gowning bench. If there is anyone who cannot afford a spare pair of shoes, please inform the cleanroom manager immediately.

Gowning Up - The Method

When you are ready to gown up, start from the top, with the cap and beard cover, to avoid shedding particles on your labwear as you dress. All your hair must be under the cap. Make sure no stray strands are sticking out before entering the lab. Hair and dandruff are common contaminants, which can be easily avoided by paying attention to your attire. Put on your suit, and make sure it is zipped all the way up with the collar turned out. Get your booties (with the shoes you are storing under the bench) and sit down on the bench. This bench separates the "clean" and "dirty" areas of this front room. The gowning area is "dirty", while the area beyond the bench is "clean". Subsequently, you should put on a shoe cover and swing your leg over the bench so that the sole of the shoe cover makes contact only with the clean floor. (Conversely, when removing your shoe covers, you should do so before stepping into the "dirty" area.) Do the same for the other foot before proceeding to put on gloves, which are found in size-labeled boxes in the bookshelves next to the doors leading into the cleanrooms. No one may enter the lab without gloves. Safety glasses are also strongly encouraged: some pairs can be found in the bookshelf or users can get theirs from VWR or chemistry stores. UV and chemical splash goggles can be found in the bookshelf and also next to the mask aligners. Splash goggles or full facial protection must be worn when working at the wetbench. These goggles also protect against UV light and must also be worn when doing mask exposure. **NB: the safety glasses will NOT protect you against UV light, only the splash goggles will.**

Gowning: For the sake of cleanliness, and as a courtesy to colleagues, suits should be changed 1x/ workweek, especially in warm weather!

Three types of gloves are commonly used in the lab. Each has a particular application and they are referred to as follows:

- a) **Latex Gloves** (latex, tan coloured):. These serve primarily to protect lab surfaces from contamination from dirt and oils on your hands. Must be worn at all times in the lab.
- b) **Triple Polymer, Chemical Resistant** (tan colored): Located by the door to the labs. These must be worn whenever you work with caustics or corrosives. Be sure to leak check them before use by inflating them, submersing them in water and checking for bubbles. *These gloves must also be worn when working with HF.*
- c) **Nitrile Gloves** (white): These serve a purpose similar to the latex gloves but offer different chemical protection.

A chemical compatibility chart is available next to the gloves. You must make sure that the gloves you choose provide adequate protection against the chemicals you will be using.

Stock

Safety & Chemical Stock

Before proceeding into the Cleanroom, note that there are certain stock items available in this area for your convenience, such as bottle carriers. Many commonly used chemicals, such as acetone, sulfuric acid and buffered hydrofluoric acid, are kept in metal chemical cabinet and under the wetbench in the yellow (lithography) room. The lab manager maintains an inventory of chemicals and can help you if the stock inside the cleanroom runs out.

Note: The cleanroom supplies most common chemicals such as solvents, acids and photoresist. However, due to the small usage base of the AMPEL Nanofabrication Facility, each user is expected to purchase his/her own supply of "special" chemicals.

Transporting Chemicals Safely

When bringing chemicals into the lab, you must use the safety bottle carriers provided in the gowning or monitoring areas. When you are finished with the carriers, PLEASE return them to this area so that they will be available for others to use. Also, be sure to check your immediate work area and the yellow room for open bottles of the desired chemical before bringing a new bottle into the lab.

Miscellaneous Supplies

The bookshelves next to the stainless steel bench contain several miscellaneous supplies such as cleanroom wipes and cleanroom paper. Additional supplies will be added as time progresses.

Entering the Lab

Sticky Mats

As you enter the lab you will see a mat on the floor known as a sticky mat, and it is just that. Its purpose is to remove particles from the bottom of your shoe covers before entering the lab, so be sure to step on it firmly. These mats have many layers. If you notice that the mat is dirty and has lost its stickiness, please peel off the top layer to expose a new sticky surface underneath. Note that the layers are numbered in a corner to prevent your accidentally peeling off more than one. The old, used layer can be discarded in the trashcan.

Lab Construction - Service Chases

One of the first things you may notice about the lab's construction is its modularity. This type of construction allows for a good deal of flexibility. Especially useful is this design's ability to isolate the utilities from the clean areas of the lab. You will notice that each lab room is separated from the other by what is known as a 'service chase'. These areas house the "dirty" equipment (mechanical pumps, cylinders) and allow technicians easy access to them. Students are not usually permitted to enter the service chases except to turn on gas bottles or in the case of an emergency.

Safety Equipment

As you walk through the lab, please pay particular attention to the locations of the **safety shower, eyewash, first aid kit, fire extinguisher, and emergency exits**. These will be pointed out to you during the tour. You will see that there is **safety shower, eyewash** and first aid supplies in the gowning room.

Please make every effort to be conscious of the locations of safety equipment at all times when you are in the lab. Know where the phones are located - each posts emergency numbers. When you enter a room, make a mental note of the nearest eyewash, safety shower, fire extinguisher, phone and emergency exit. This knowledge could save you precious seconds if an emergency should arise.

Telephones

The lab has fully functional telephone sets located in the lithography (yellow) and the thin film rooms. You can call most staff members directly at the numbers posted by each set. The phones may be used to make outside local calls and long distance calls using the *55 codes. The phone in the lithography room is cordless while the thin film room phone is equipped with a long cord; this is useful for superusers when troubleshooting equipment during a service call. Out of courtesy to other lab users, please limit your use to calls related to cleanroom business or very short calls. If you must engage in a long conversation, leave the lab and make your call on another telephone system. Cell phones may be used in the lab but please do not unzip your bunny suits to answer in the cleanroom. The phone number is 604-822-1653 and should only be given out for work related (preferably cleanroom) purposes. Do not give out this phone number for personal calls.

The Rooms

Lithography (Yellow) Room

On the left side of the lab is the lithography room, also called the yellow room. This room has yellow filters on all light sources to allow photolithographic processes to be carried out. This is a class 1000 area. The lithography rooms contains a dry bench, a wetbench, a spinner, 2 mask aligners, a drying oven, an optical microscope, a scanning electron microscope (with e-beam writing capability) and assigned glassware storage cabinets (**NB:** All users should wash and dry their glassware before storing it in the cabinets). Both the wet and dry benches are equipped with laminar flow hoods. The dry bench has a UV ozone cleaning chamber (UV goggles required). The wetbench houses the spinner as well as two digital hotplates and an ultrasonic bath.

Thin Film Room

On the right side of the lab is the thin film room. This room contains 2 plasma etchers, a plasma CVD deposition system, e-beam and resistive heating evaporator, sputter deposition chamber, a rapid thermal annealer, a wire bonder and an alpha-step profilometer. The thin film room is class 10000.

Chemical Waste Disposal

Empty Chemical Bottles

When you have emptied a chemical bottle, plastic or glass, rinse it thoroughly **3 times**. While rinsing bottles that contained acids or chlorinated solvents, wear a face shield and chemical resistant gloves. Once it has been rinsed 3 times, the bottle can be taken out of the lab. Clean **glass** bottles go in the grey metal trashcan located directly under the desk in the reception area. Clean **plastic** bottles go in any regular trashcan.

Mixing Chemicals Can Be Dangerous!

It is imperative that chemicals be discarded properly. Mixing chemicals carelessly can be extremely dangerous. Acids, bases and solvents should never be mixed together in the same container as this is a potentially explosive reaction. There are labeled disposal bottles under the wetbench for acids, unchlorinated organic solvents and chlorinated/fluorinated organic solvents. It is important to dispose of waste chemicals in their proper waste containers. Very small quantities of acids or bases may be dumped in the sink and washed with large quantities of DI water; make sure that the entire sink, sides and bottom, is thoroughly rinsed with DI water afterwards (use the water gun).

Undiluted, non-water-miscible and chlorinated solvents, such as TCA, photoresist or chlorobenzene should **NEVER** be dumped in the sink. Disposal of solvents in this manner is not only an environmental threat, it will also damage the building's plumbing. Chlorobenzene should in fact be saved in a clean and **IDENTIFIED** capped bottle for personal reuse. Photoresist that is significantly diluted with acetone can be poured into the plastic organic waste bottle underneath the wetbench.

If you need to dispose of a chemical for which no waste container already exists, the waste should be placed in a loosely capped plastic bottle with a label clearly identifying the contents. The bottle should be placed underneath

the wetbench but care should be exercised to ensure that incompatible chemicals are not stored next to each other. You **must** clearly identify the waste bottle with your name and the material identification and descriptive information. You **must** also notify the cleanroom manager and/or lab assistants. If the waste containers are full, notify the cleanroom manager or a lab assistant.

Wipes

Wipes that have been soaked with acids or bases should be thoroughly rinsed in the sink before being disposed of in the white garbage can inside the lithography room. Wipes that have been soaked with solvents should be identified and left to dry under the laminar flow hood (wetbench). Once they have dried, they may be disposed of in the white garbage can.

Chemical Spills

All spills, whether at a sink or work surface, must be cleaned up at once, *when you are 100% certain that it is safe to do so*. Leave work areas as you would like to find them. **Reminder:** water and acid/HF look the same. If an accidental spill occurs and you are concerned about safety, evacuate the room, secure the area and use the telephone in the other room to report the spill and consult for a plan of action. **Reminder:** solvents and cryogenics can be *fatal* with less warning signs than acids. Always know the telephone number where you can reach someone (buddy system).

Maintenance

Cleanliness

The cooperation of all students and users is required to keep our cleanroom clean. On a weekly basis, the janitorial staff empties the trashcans, washes the floors and peel off the tacky mats in all rooms. They are neither responsible nor allowed to wipe down (cleanwipes and iso-propanol) any of the cleanroom equipment. This is the responsibility of the users. The walls and other surfaces are wiped down by periodical cleaning bees. These typically occur once per semester but may be called more often as needed. It is expected, as a matter of cleanroom etiquette, that users wipe down their equipment after each use in order to maintain cleanliness.

Equipment Maintenance

The cooperation of all students and users is required to keep our equipment up and running. Whenever a piece of equipment fails, the cleanroom manager, or the corresponding superuser, should be notified immediately.

Equipment Reservations

An equipment reservation sheet is found in the binder on the reception desk. This has so far been used very informally but may become more formal in the future due to increased use.

Cleanroom Procedures and Policies

The following are established procedures and policies that must be observed when working in the Nanofabrication Facility. Failure to do so puts everyone's work, including your own, at risk of contamination. Please proceed accordingly.

General Information

The following items are considered "contamination sensitive":

- Wafers or silicon samples;
- all equipment that comes into contact with wafers: tweezers, Teflon®
- and/or polypropylene cassettes, certain machine parts.

These items are handled only while wearing a fresh pair of gloves. They should never be placed directly on any table surface, but only on cleanroom wipes, and should always remain under HEPA filters.

Cleaning New Lab Gear

When you receive your new lab equipment, such as wafer boxes with cassettes, tweezers, etc., you will want to clean them. There are established procedures for doing this. In general *anything* that you bring in from the outside should be wiped with cleanroom wipes and iso-propanol before being brought into the cleanroom areas. Perform this procedure on the stainless steel gowning bench; don't forget to also wipe the bench after you finish.

For further cleaning of critical items and tools, such as glassware, tweezers, wafers, etc., Standard Operating Procedures (SOP) are established. See the SOP folder on the computer next to the optical microscope in the lithography room for SOP and links to other university procedures. These items should be cleaned on the wetbench.

Taking Notes and Standard Operating Procedures

Never bring a regular paper logbook into the lithography room but use the provided cleanroom paper instead. If you need to consult outside notes, you may leave your regular logbook on the gowning bench and consult (or copy to cleanroom paper) as required. Ideally, only electronic notes should be brought into the lithography room. The computer next to the optical microscope has a bunch of Standard Operating Procedures (SOP) or recipes. If you have regular need of an SOP which is not already available but could be of general interest, please write one up, or find it on the web, consult with the superuser and cleanroom manager and save it in the SOP folder. If it is a recipe unlikely to be of benefit to other users, please create your own folder and save your particular recipes there.

The thin film room is class 10000 but the same rules still apply.

Tweezers

Do not use metal tweezers to immerse your wafers into solutions of any kind. They will contaminate the solution and you may wind up depositing metal ions on your wafers. If you must immerse tweezers into a solution, only Teflon[®] tweezers are permitted, but you should note that these are clumsy to use. You may want to maintain a separate pair of tweezers for handling samples with photoresist.

Gloves

Gloves are available and are paid by your supervisors (we trust the honor system). A fresh pair should be put on each time you handle your wafers, or anything that will touch wafers and machine parts that will contact wafers.

Wafer Handling

Always wear fresh clear gloves when handling your wafers. Do not allow your gloves to touch your face.

Never talk or breathe over your wafers. There is a great tendency to do this when working with the microscopes. Saliva is the most common contaminant in the lab. Smokers should be aware that they exhale a lot of particles (mostly tar and carbon containing compounds) immediately after smoking. Out of respect of your own work and that of others, if you must smoke, please allow yourself at least an hour before coming in the cleanroom.

Isolate wafers with photoresist from your clean wafers. You may want to dedicate a separate box to wafers with photoresist, or at least one side of a box. Use separate tweezers to handle 'clean' wafers and those with photoresist.

Never lay your wafers down on a table surface. Your wafers should contact only clean wipes or lab equipment.

Work Storage

Ask the cleanroom manager for shelf space in the rooms you use most often. Alternatively, you may store labeled closed boxes in the shelves on the "dirty" side in the gowning room (remember to wipe them down with iso-propanol when taking them back in the clean areas). Always store your parts after you have completed your work for the day.

Space: The cleanroom has limited space for lab member storage. Members are asked to expediently clean out shelves and then remove their nametags and marker tape when they are no longer needed. Send e-mail to beaudoin@physics.ubc.ca so these spaces can be reassigned. Space that has not been used in a long time will be reassigned to more regular users.

TABLE TOPS AND WORK SURFACES ARE NOT MEANT FOR LAB MEMBER STORAGE!

Teflon[®] is a registered trademark of DuPont.

M. Beaudoin, University of British Columbia
Rev. 00 – 01/04

Adapted from the Microfabrication Laboratory at the University of California, Berkeley.
K. Voros, U.C. Berkeley
Rev. 00 - 6/95
R. Hamilton, U.C. Berkeley
Rev. 01 - 7/99
M. Kushner, U.C. Berkeley
Rev. 02 - 5/01
Rev. 03 – 10/03

THE UNIVERSITY OF BRITISH COLUMBIA
Advanced Materials and Process Engineering Laboratory (AMPEL)
Nanofabrication Facility (Cleanroom)



Appendix I: USER QUALIFICATION FORM

This document certifies that (please print user name)

has been qualified to use the following piece of

equipment : _____

as a (please check 1):

User

Superuser .

User signature: _____ date _____ .

Qualified by (print superuser name) _____

who is an approved superuser of that equipment.

Superuser signature: _____ date _____ .

Approved by Mario Beaudoin, Nanofabrication Facility Manager :

Signature: _____ date _____ .

Appendix III: Safety Resources at UBC

The cleanroom follows the UBC safety guidelines. For more information, please consult the UBC Health and Safety website at <http://www.safety.ubc.ca>. Information on MSDS sheets can be found through that website; specifically at <http://www.safety.ubc.ca/inner.php?scid=15&pid=101>. Some MSDS sheets for common chemicals can be found in a folder called MSDS on the computer next to the optical microscope in the lithography room.

UBC Health and Safety give a wide range of safety courses. The course entitled “Introduction to Chemical Safety”, or its equivalent, is compulsory for anyone, staff, students and outside users, who work in any UBC research laboratory. This course is given periodically by UBC health and safety. Please consult their website to be register for the next available session <http://www.safety.ubc.ca>. The AMPEL cleanroom manager keeps a copy of the certificate issued by UBC H&S.