HEALTH AND SAFETY PLAN

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A. INTRODUCTION:

1. Scope:

The policies and procedures in the Washington Technology Center (WTC) Health & Safety Plan apply to the WTC office and IT spaces in Fluke Hall, suites 300, 310, 334, 125, 135, 115B1 &2, 115F, 238.

The Health & Safety Plan is publically available to all at the following locations:

- Fluke suite 310 (Middle Bay) on the small book case in the NW corner in a labeled binder
- The Simplex ECP Panel Room located on the first floor, on the East exterior
- The WTC Intranet
- The WTC MFL website at http://www.watechcenter.org/lab
- For the WTC Microfabrication Laboratory (MFL) procedures (SOP) see appendix "B" and refer to Mike Hjelmstad at mhjelm@watechcenter.org 206-616-3855 or click the link here:
  http://www.watechcenter.org/sites/default/files/docs/labusermanual.pdf
  ttp://www.watechcenter.org/lab

2. Health and Safety Policy:

This Accident Prevention Program, or Health and Safety Plan, shares the commitment of the University of Washington to provide a "safe and healthful environment for all individuals associated with the institution, including faculty, staff employees, hospital patients, and visitors" (University Handbook Vol. IV, Part VI, Chapter 4). It follows UW policy set in the Administrative Policy Statements (APS) 10.3, and is consistent with requirements in the Washington State Industrial Safety and Health Act (WISHA) (WAC 296-24, 296-62 and 296-800) which is administered by the Department of Labor and Industries (L&I).

3. Responsibility:

The Dean, Director, Chairs and Supervisors are responsible for maintaining safe work practices in their respective units, including required health and safety training. We understand that it is University policy that this responsibility can neither be transferred nor delegated (University Handbook, Vol. IV, Part VI, Chapter 4, Section 1.A). Our department requires all employees to comply with health and safety regulations, with departmental policies and procedures that apply to their own conduct on the job, and to report accidents, injuries, and unsafe conditions to their supervisor.

4. Safety Coordinator:

We have chosen one individual to serve as a Safety Coordinator for our department (see "Back Page"). This person is the WTC Facilities Coordinator, Pamela Thomas, and has been given adequate authority to carry out the following responsibilities:

- Promoting this Health & Safety Plan in our organization
- Updating this Plan, at least annually, with management approval
- Assist with scheduling employee safety training as requested by supervisors (special note: lab orientations, safety training and training tracking is coordinated with the lab manager as named in the beginning of this document. University required staff training and training tracking is coordinated through the WTC H/R appointed person, Teresa Rainwater.)
- Coordinating with UW Environmental Health & Safety (UW EH&S)
- Provide assistance to supervisors and employees as needed to resolve safety complaints
- Keeping safety bulletin boards current
- Maintaining our organization's safety records
- Keeping the department head aware of current safety concerns.

B. FUNDAMENTALS: 8 KEYS

1. New Employee Health and Safety Orientation:

WTC HUMAN RESOURCES:

All our new employees, including those that are permanent, temporary, or part-time, must receive instruction for the following:

a. Reporting procedures for fire, police, or medical emergencies;
b. Evacuation procedures during an emergency;
c. Location of fire alarm pull-stations and fire extinguishers; Employees using fire extinguishers are recommended to take fire extinguisher training;
d. Procedures for reporting all accidents and incidents to their supervisors and completing a written online report using the UW Online Assisted Reporting System (OARS)
e. Procedures for reporting unsafe conditions or acts to their supervisors, and, when possible, taking action to correct unsafe conditions;
f. Exact location of first-aid kits and identification of first-aid certified employees;

LAB MANAGER:

g. Description of UW and departmental Hazard Communication Program for chemical hazards to which they may be exposed;
h. Identification and explanation of all warning signs and labels used in their work area;
i. Use and care of any personal protective equipment they are required to use;
j. Description of safety training they will be required to attend for their job. This includes General Asbestos Awareness Training which is mandatory for all employees.

The following procedures describe how we provide the above instruction, how and where records are kept, and what person is responsible for providing training. Samples of checklists we use are included (or referenced) here.

All new WTC employees must complete a review then sign, date and check off the Health & Safety Orientation with Human Resources for the applicable section(s) above upon new hire orientation. Administrative records are kept with WTC H/R. Further lab training is kept with the WTC MFL lab manager and UW EH&S training records.

2. Emergency Evacuation and Operations Plan (EEOP):

The WTC EEOP is based on Fluke Hall as containing several combinations of non-related, multi- disciplinary public and private e**n**tities

The WTC EEOP contains:

a. Building floor plans that show safety equipment and exit pathways;
b. Evacuation procedures;
c. Evacuation assembly point(s);
d. Methods for accounting for staff, students, visitors;
e. Areas of refuge for mobility-impaired occupants.

For more information, you may call the UW EH&S Building and Fire Safety Office at 206.543.0465.

All department staff must be trained in the EEOP. The WTC EEOP is provided to all Fluke lab managers and PIs for them to ensure their departments are trained and adhere to the WTC EEOP. If an employee moves to a new location, the EEOP for their new location must be reviewed for that particular new work site.

3. Accidents:

a. **Medical Emergencies**:

All medical emergencies must be reported to the nearest Emergency Medical Services (EMS), usually 911. Our department uses the following method to summon EMS help.

WTC staff and Fluke Hall occupants use 911 to summons EMS help. If using cell phone, dial 911 then tell the dispatcher you are on the University of Washington campus (Seattle) and the nature of the emergency. For fire, pull the red alarm then call 911. For hazardous chemical spills, pull the yellow alarm in the MFL or the red outside MFL then call 911. Perform evacuation procedures in the WTC EEOP.

A “Blue” Emergency Kiosk phone is located on the ground-level, north exterior promenade of Fluke Hall.

Harborview Medical Center Emergency dial 3000

b. Motor Vehicle Accidents

For motor vehicle accidents, please see Fleet Services

If an Employee is injured, report using Online Accident Reporting System (OARS)

Report form to supervisor and EH&S:
All accidents *and near misses* must be reported to the employee's supervisor and EH&S as soon as possible. Near misses are valuable opportunities to correct unsafe situations, which under slightly different circumstances, would result in serious injury. A report may be filled out by the employee, the supervisor, or both using the Online Accident Reporting System (OARS) at:
http://www.ehs.washington.edu/ohsoars/index.shtm.

Copies of this department's completed forms are distributed to the following people:

- Immediate supervisor of the party involved
- UW EH&S
- WTC Facilities Coordinator & Safety Representative, Pamela Thomas

Accidents and Incidents
Reporting an Accident, Incident, or Near Miss
Report all work-related injuries and illnesses or near-miss incidents to your supervisor as soon as possible. For WTC, report to Facilities Coordinator.

Accident reports need to be submitted to UW Environmental Health and Safety (EH&S) within 24 hours. In case of serious or fatal accident or hospitalization, notify EH&S immediately at 543-7262 (within 8 hours); after hours contact the UW Police Department (UWPD) Dispatch by dialing 911 in order for the EH&S Staff On Call to be notified. Do not move any equipment involved in these types of serious accidents until EH&S has clearance from State investigators.

If the WTC Facilities Coordinator is unavailable within the needed timeframe for reporting, call EH&S at the above number for assistance with the OARS reporting. Upon completion of incident reporting, notify the WTC Facility Coordinator and the immediate supervisor of the incident via e-mail, phone or in person as soon as possible.
☐ **Enter the Online Accident Reporting System (OARS)**

Reporting a Fire
"Fire" is defined as any instance of open flame or other burning in a place not intended to contain the burning.

All fire emergencies and explosions must be reported immediately regardless of size and nature by phoning 911 and/or activating the fire alarm system. The level of response will vary based upon the information provided.

To comply with agency reporting requirements, all incidents including minor fires that self-extinguish and those that do not require emergency assistance or evacuation must be reported to EH&S within 24 hours. EH&S investigates all fires to determine their cause, provide consultation and to document the incident for reporting purposes. Please call (206) 616-5519 or email uwfire@uw.edu to report fires/explosions to EH&S.

Reporting Chemical Spills

Spills Management

Emergency Contacts

Major Spills
If you have a spill, and the spill
is uncontained and endangering other people and/or
has the immediate potential to cause a fire
pull the nearest fire alarm to evacuate the building and alert the local Fire Department. The fire alarm is the fastest way to evacuate the building and get help.

Minor Spills
If the spill is contained and there is no potential for fire, but the spill has caused or will likely cause injury, *call emergency personnel* using the numbers below.

Your location	Phone number
All UW campuses and UWMC	911
Cell or off campus phone	911
Harborview	3000 or 911

You will be asked about your location, the size, type and risks of the spill, and the details of the injury.

Exposure Assessment
If you have been exposed to a spill and are not sure whether or not you should seek medical attention, you should request an exposure assessment from Hall Health.

Location	Phone number
Employee Hall Health Clinic	206.231.3081
Campus Health Clinic (for students)	206.685.1026

Spills cleanup
If the spill is contained and there is no immediate risk of injury, then decide whether or not you will be able to clean up the spill yourself:

Cleanup

an outside contractor to do the cleanup for you, call EH&S spill advice line at 206.543.0467 during business hours. After hours, wait until the next business day or call 206.685.UWPD from any location and ask to speak to "EH&S Staff On Call".

Call 206.543.0467 for assistance with spills that fill your laboratory with toxic vapors. You cannot clean up these spills yourself. The use of respirators requires prior medical evaluation, training, and fit testing, and even if you have been trained, you are not allowed to do cleanups because the vapors may overwhelm the respirator, which are often designed only for normal use.

You can clean up the spill yourself if you know what chemical was spilled and that hazards of that chemical, can you protect yourself from these hazards (with gloves, eye protection etc), and have and know how to use a chemical spill kit for that chemical.

EH&S has created a custom general purpose spill kit for spills up to about a gallon in volume. The spill kit contains materials that neutralize an acid spill and absorb small amounts of liquids. It also contains handy items such as goggles, gloves and hazardous waste labels. It is available at Chemstore, 206.543.1728, and Biochemistry Stores, 206.543.1624, and you can order it from VWR through eProcurement (part #TXGENERALSPILL) for $50.

The spill kit contains the following:

Absorbents	Neutralizing material	Containers and supplies	Protective gear
Five spill pads, universal for acid, base, solvents and oil (absorbs about 5 liters of liquids)	1 box baking soda for neutralizing acids (neutralizes about two liters of concentrated acid, half that if dibasic)	4, 20 x 30", heavy duty (6mm) hazardous waste plastic bags	1 pair Silvershield gloves, protective against most chemicals
		1 five gallon reuseable screw top plastic drum. Use to store all kit supplies and later to hold spill waste for pickup by EH&S.	1 pair goggles
		Snap together dust pan and brush	8 pairs of Microgrip powder free nitrile gloves
		Waste collection form and labels (available free from EH&S)	

Chemical spills: http://www.ehs.washington.edu/epo/spills/chemspills.shtm

Biohazardous spills: http://www.ehs.washington.edu/rbsbiosafe/spillsbio.shtm
Mercury spills: http://www.ehs.washington.edu/epo/spills/hgspills.shtm
Oil spills: http://www.ehs.washington.edu/epo/spills/oilspills.shtm

Call the following numbers for assistance in writing spill procedures:

Type of Spill	Phone number
Chemical, mercury or oil	206.543.0467
Biological	206.221.7770
Radioactive	206.543.0463

Finally, don't work alone if possible, especially on weekends when no one else is there to help you in the event of an emergency.

c. Investigation:

All accidents and near accidents must be investigated by the supervisor who then summarizes the details and corrective measures in the above report. EH&S and the department's organizational safety committee review the report. Assistance from EH&S is available by calling 206.543.7388.

4. First Aid Kits and CPR Given:

Quick and effective first-aid for an injured University employee results from the availability of strategically located first-aid kits and first-aid/CPR certified individuals whenever department staff are working. Adequate employee *access* to these resources is addressed in this section.

a. Department First Aid

Consistent with the UW First Aid Response Plan (APS 10.5), certified first-aid and CPR assistance is available to department employees by contacting UW Emergency Response Teams.

Related department *training* requirements are addressed later in section C.4 First Aid and CPR Training. Names and phone numbers of employees who are first-aid/CPR certified are listed on the "Back Page" of this document and on the outside of first aid kits.

b. First Aid Kits

Locations and sizes of first-aid kits in our department are listed below. First-Aid Kits are inspected periodically so they can be restocked before running out of an item. Names and phone numbers of those employees who are CPR trained and those employees who are responsible for first-aid kits are listed on the outside of the kits and on the "Back Page" of this document.

The WTC office red first aid kit hard cover case labeled “First Aid” on the outside is located on the third floor south, in the small kitchenette, and at the right side of the Microwave. It is inventoried and stocked by the WTC Facilities Coordinator & Safety Representative, Pamela Thomas.

The WTC first floor lab kit is located in 135.

5. Safety Problems: Reporting and Resolving:

Employees are encouraged to report safety concerns to their supervisor. If employees do not feel they can do this, or have done so and do not feel the problem has been resolved, they may discuss the situation directly with their safety coordinator or safety committee representative. Assistance from EH&S is available, if needed, to resolve a problem. Safety problems may be reported online using OARS as you do for accidents/incidents. Other departmental procedures for reporting and resolving safety problems or potential workplace violence are described below:

Call 911

If safe yet concerned, report threats to Safe Campus at 206-685-SAFE (7233)

Additional resources can be found at UW Care Link
http://www.washington.edu/admin/hr/benefits/worklife/carelink/index.html

For UW safety guards, call 206-685-WALK (9255)

Refer to Workplace Violence Reporting here: UW Policy and Procedure on Workplace Violence

File Online Accident Reporting System (OARS) if injured.
University Medical Centers Employees Report to Public Safety Office
Complete a PSN report.
Complete an OARS report.
University of Washington Medical Center Public Safety

6. Safety Meetings: Supervisor Leadership

Supervisors can promote health and safety in formal safety meetings or in regular staff meetings, but either way, discussion of safety issues needs to be documented. Formal safety meetings are held as described below, including organizational policy, meeting frequency, responsibility for minutes, location of minutes, and how part-time employees can participate or be informed.

WTC Facilities & Safety Coordinator keeps safety committee notes available to all staff. Updates and noteworthy information, such as new training links and news, is communicated via e-mail with staff and Fluke tenants directly. Other non-urgent information is communicated via the initial orientation and staff meetings as issues arise. (Staff meetings are weekly)

Training updates are conducted annually or as needed in context.

Annual asbestos awareness training notifications are sent to all employees and student help via e-mail instructions referring to the training link:
https://www.ehs.washington.edu/pubcookie/train/asbestosg/index.shtm

This was last coordinated October 7, 2010 by the Safety Coordinator.
* For WTC MFL specific procedures and training, refer to the lab manager, Michael Hjelmstad at mhjelm@watechcenter.org 206-616-3855

For procedures in general, the following applies:

WTC is a small organization of 18 – 22 employees at any given time, many of whom work from remote posts at any given time.

Facilities Coordinator & Safety Representative, Pamela Thomas, assists with training notifications and information processing. WTC H/R, Teresa Rainwater archives training for office staff. MFL Lab Manager, Mike Hjelmstad assists with training notifications and information processing and archiving for lab staff.

A generic new employee safety orientation checklist can be found on the EH&S web-site at http://www.ehs.washington.edu/ohshsplans/index.shtm.

7. Health & Safety Committee Participation:
Health & Safety Committees at three organizational levels help determine unsafe conditions and procedures, suggest corrective measures, and obtain the participation of all UW personnel. At the Organizational and University-Wide levels, fifty percent (or more) of the representatives are elected by employees and fifty percent (or less) are appointed by management. Safety issues may originate at any level. Health & Safety Committees are required by Washington State regulation (WAC 296-800-14005). A listing of committees and current members may be found at the EH&S web-site: www.ehs.washington.edu (click on Safety Committees).

a. Departmental Health and Safety Teams

Departmental Health & Safety Teams deal with "front line" issues. Large departments may especially benefit from this centralized approach to health and safety issues. In addition to providing a pathway for communication between different sections, teams involve employees in the process of identifying and resolving safety issues.

WTC does not have a formal health and safety team. Instead, health and safety issues are discussed in staff meetings (see section B.6) and as part of our Organizational Health & Safety Committee. Also, a student or staff member can approach the WTC safety representative, Pamela Thomas, at any time.

b. Organizational Health and Safety Committees

The University is divided into eleven organizational groupings, each one represented by an *Organizational Health and Safety Committee*. This committee deals with issues the members may have in common but can handle more effectively together. Each elected member represents all units of that organizational group, including his/her own.

Our department is represented on the Group # **9** Organizational Health & Safety Committee.

The **Group # 9** Committee reports to the following executive Michael Glidden of College of Engineering, who is represented on the Committee by __Michael Merrill of UW EH&S.
Our current representatives are identified on the "Back Page" of this document.

c. University-wide Health and Safety Committee

In addition, to provide consistency and oversight, a *University-wide Health and Safety Committee* has been established. Its members come from the official organizational committees. Safety issues referred to this level are relevant to the entire University community. The member(s) who currently represent us from the Group # _9_ Organizational Health & Safety Committee are listed on the "Back Page" of this document.

8. Safety Bulletin Boards

Our departmental safety bulletin boards are used for posting DOSH (formerly WISHA) posters.

Safety posters, notices and safety newsletters are posted on the third floor bathroom corridor in the middle of the hallway.

Safety committee minutes and incident reports are kept on the third floor in binders on a bookcase at the WTC Facility Coordinator desk.

Accident statistics and other safety education material may also be posted.

WTC Lab training schedules are located in first floor 135 MFL lab for WTC where all employees, students, and visitors can see them (WAC 296-800-19005) and at all University reference stations.

C. ACCIDENT/ILLNESS PREVENTION: 6 KEYS:

1. Identification of hazards:

This is the foundation for our Accident Prevention Program. The boxes we have checked in the following chart, "*Typical Work Site Safety Issues To Address*," indicate health and safety concerns present in our own department.

- We consulted knowledgeable staff to identify possible hazards.
- We reviewed records of past injuries to understand their causes.
- We developed Laboratory Safety Manuals for our laboratories (including Chemical Hygiene Plans) if required.

- We visited all work areas, and examined processes from beginning to end in order to record possible hazardous situations.
- We developed inspection checklists (see section C.3 below).
- We applied recommendations from inspectors outside our department, such as EH&S.
- We consulted the Washington Administrative Code (WAC) Chapters 296-24, 296-62 and 296-800 for General Safety and Health Standards and Occupational Health Standards established by the State Department of Labor and Industries (L&I), as well as the University of Washington Administrative Policy Statements (APS), 10.3.
- We performed Job Hazard Analyses (JHA). (See discussion following the Chart below.)

"Typical Worksite Safety Issues to Address" Chart Instructions

The chart on the next page is a tool to help you identify issues that are addressed by safety regulation. You don't have to include the actual chart in your Plan, but it would be a good idea to do so when requirements apply to your workplace. (Double left-click on any box in the left column you want to check.) Safety items you have checked indicate issues you need to evaluate. These must be included in your safety Plan, along with methods you have developed to reduce a hazard if one exists. Section C.2 Reduction of Hazards explains how to do this. EH&S help at 206.543.7388.

Check All That Apply	Typical Worksite Safety Issues To Address	Offices	Class-rooms	Hosp. / Clinics	Labs	Shops
	Applies: A=Almost Always, B=Commonly, C=May Apply, Blank=Rarely Applies					
X	Emergency Procedures: Fire, Other (EEOP)	A	A	A	A	A
X	Earthquake Preparedness	A	A	A	A	A
X	Housekeeping Hazards	A	A	A	A	A
X	Slip/Trip Hazards	A	A	A	A	A
X	Electrical Equipment & Wiring	A	A	A	A	A
X	Emergency Escapes (Egress) Maintained/Unlocked	A	A	A	A	A
X	Obstruction-Free Aisles	A	A	A	A	A
	Stacks of Stored Materials (Stable/Secure)	A	A	A	A	A
	Temperature Extremes: Heat/Cold Stress	A	A	A	A	A
	HazCom Right-To-Know (Written Program In Place)	A	A	A	A	A
X	Air Contaminants, Dusts, "Inert" Gases, Vapors	A	A	A	A	A
X	Asbestos (Present or Handled)	A	A	A	A	A
	Lifting >20 lbs.	A	A	A	A	A
	Repetitive Motion, Ergonomics	A	B	A	A	A
	Motor Vehicles	A	A	B	B	A
	Hand or Portable Power Tools	B	B	A	A	A
	Ladders	B	B	A	A	A
	Knives or Cutting Blades	B	C	A	A	A
X	Compressed Gas or Equipment		A	A	A	A
X	Hazardous Waste	C	A	A	A	A
X	Haz-Mat Spills: Operations, Emergency Response		A	A	A	A

X	Hazardous Materials Stored/Shipped/Transported	C	B	A	A	A
X	Laboratory Chemicals		B	A	A	A
	Radioactive Materials Used or Stored		A	A	A	
	Personal Protective Equipment (PPE)	C	B	A	A	A
	Respirator Protection, Workplace Evaluations		B	A	A	A
	Bloodborne Pathogens/Biohazards/Infectious Waste		B	A	A	B
	Welding, Cutting, Brazing		B	A	A	A
	Machinery (Machine Guards)		B	B	A	A
	Lock-Out/Tag-Out		C	A	B	A
	Confined Work Spaces / Oxygen-Deficiency			A	C	C
	Steam or Autoclaves		C	A	A	
	Lasers or UV Light		C	B	A	A
X	Flammable Liquids (Handled or Stored)		C	B	A	A
	Formaldehyde (Handled or Stored)			B	A	C
	Carcinogens			B	A	A
	Lead or Benzene (Handled or Stored)			C	A	A
	Animals (Handled or Kept)		C		A	
	Loud Noise				A	A
	Vibration From Tools/Machinery				A	A
	Heights > 4 Ft. (Possible Falls)	C	C	C	A	A
	Cranes, Hoists, Derricks, Rigging		C	C	A	A
	Powered Platforms (Personal Lifts)		C	C	C	A
	Forklifts				C	A
	Scaffolds		C	C	C	B
	Excavation, Trenching or Shoring Activities					
	BBQs					
	Food Handling			C		
	Diving					

A *Job Hazard Analysis* may be performed by the first line supervisor in the following way:

- Review job injury and illness reports (including “close calls”) to determine which jobs to analyze first.
- Involve employees in all phases of the analysis. Explain to workers that you are studying the job, itself, not checking up on them.
- Review work plans for an overview of job activities.
- First note deficiencies in general conditions, such as inadequate lighting, noise, or tripping hazards that may not be directly related to the job.
- Break the job down into steps in the order of occurrence.
- Examine each step to determine hazards that exist or might occur.
- Determine whether the job could be performed in another way or whether safety equipment or precautions are needed.
- If safer job steps can be used, write new procedures to describe specifically what the worker needs to know to perform them.
- Determine if any physical changes will eliminate or reduce the danger (e.g. redesigned equipment, different tools, machine guards, personal protective equipment or ventilation).

- If hazards are still present, try to reduce the necessity or frequency for performing the job.
- Document the assessment: job covered, task, date, and person performing the analysis.
- Review recommendations with all employees performing the job.
- Review and update the job hazard analysis periodically, especially if an accident occurs in that job.

2. Reduction of hazards:

Our department head and supervisors have complied with the requirement for a written plan in their areas of responsibility by *identifying* each of the above hazards, *evaluating* its potential risk, and *controlling* or eliminating it according to the measures described below.

When possible, we modified or designed our facilities and equipment to eliminate employee exposure to hazards. Where engineering controls are not possible, we have instituted work practice controls that effectively prevent employee exposure to the hazard. When these methods of control are not possible or not fully effective, we require the use of personal protective equipment (PPE), such as safety glasses, hearing protection, etc.

a. Evaluation

Evaluation of potential risk (probability and magnitude of harm) has been done for certain hazards. When hazards are either (1) present in an unknown or a variable amount **(such as airborne contaminants like asbestos or carbon monoxide),** or (2) subject to complicating factors **(such as extreme risk or individual medical sensitivity)**, monitoring has been done to determine the safest procedures**.** EH&S has been consulted as needed. The following describes evaluations we have made:

Refer to the MFL Lab Manual, appendix “B”, attached to the back of this document.

b. Engineering Controls

Engineering controls have been employed, whenever possible, as the preferred way to eliminate the following specific hazards **(facility or equipment design, e.g., fume hoods, guardrails, proper tool guards, walkway surfacing).**

A building- wide Emergency Communication Panel (ECP) system and an additional lab ECP relay emergency information to the UW fire department, City of Seattle fire department, City of Seattle hazardous response teams and the WTC MFL manager via dedicated data lines that report to a signal response relay system. These ECP’s are synchronized with the building fire alarm systems, thus activating all simultaneously in a fire and safety emergency.

Other phone numbers:

- Symplex monitoring Systems:

  - The "silent night" auto dialer on the sensor Emergency Communications Panel (ECP) that services the MFL and can also sense other hazardous gases in the parameter of the sensor is 206-685-6641. This number dials from the University to Simplex using 206-685-6752 and is digitally recognized for emergency alert. This sends out appropriate UW FOMS, Fire and Haz Mat signals for the degree necessary for the type of alarm. This system is approved for the indications and response relay.

- Mike Hjelmstad, WTC MFL lab manager emergency cell: 425-894-6243
- UW FOMS: 685-1411- ask for 24/7 EH&S assistance via FOMS
- UW Environmental Health & Safety: 206-543-7262
- "Silent Night" auto dialer dedicated phone lines
  - 206-685-6641- primary
  - 206-685-6752- alternate back up

c. Administrative Controls

Administrative controls, the way a job is done, have been used to reduce some of the hazards in our department, and on-going training is an inherent part of our safety program (see section C.5).

EH&S inspections are conducted by the UW official respective representatives on a semi- annual basis. Building fire systems checks are conducted by the UW official respective representatives on an annual basis. Fire Drills for EEOP are conducted by UW Fire Safety quarterly. Building walkthroughs are conducted at random by the Facility Coordinator & Safety representative. Lab PI's are responsible for checking and reporting for training and compliance on an ongoing basis.

d. Personal Protective Equipment

None required for administrative staff.

For the WTC MFL lab, please refer to appendix "B" attached to the back of this document. Hazard assessment and training documentation is also located in the WTC MFL lab room# 135 for lab staff and users.

The University of Washington EH&S team provides support with on-site staff in an emergency when other PPE is required outside of the lab manual.

The following information is required (UW APS10.4): Hazard Assessed, (site, evaluator, date, supervisor verifying)

For WTC, every new lab user is provided with the LAB SOP Safety Manual and is responsible to apply the information at all times while using the lab. New information and updates are provided as required on an ongoing basis.

For other lab tenants in Fluke Hall, their respective on-site lab supervisor is responsible for managing their lab safety as required in this document. Their training records are to

be on file with UW EH&S Training and their on-site lab supervisor in their respective room/lab in Fluke to be accountable for by their respective college department.

3. Safety Inspections

Safety Inspections for WTC and Fluke Hall are conducted semi-annually by the UW EH&S staff. They send a report with recommendations to the WTC Facilities Coordinator for issues concerning WTC third floor administrative areas and to each lab manager in Fluke for individual labs. They then check back in three weeks to be sure all requirements and recommendations are met. Each lab manager in Fluke is responsible for their compliance.

4. First Aid and CPR Training

Names and phone numbers of employees who are first-aid/CPR certified are listed on the "Back Page" of this document.

The UW Police Department provides adequate access to emergency first aid for our employees (see section B.4). Consequently, we do not require employee training in First Aid and CPR. However, employees are encouraged to take first aid.

5. Safety Training: On-Going

To ensure an effective health and safety program, we continually re-educate employees on how to work safely with all applicable hazards. Supervisors are responsible for this training and for seeing that safe practices are followed. Listed below are the training requirements for hazards identified in our department, how training is obtained, and how often it must be renewed Training records, including completion dates, are kept to maintain program continuity and to satisfy legal requirements.

Documentation is kept by UW EH&S- training records division for WTC and non-WTC lab users.

Hazard Type of Training Frequency Person/Position

Workplace violence training is required for all-staff by the University upon hire. These records are kept by the University H/R systems.

WTC lab staff requirements- see appendix "B" attached to the back of this document.

Additional information regarding training requirements may be found on the EH&S home page under "Training Information". Supervisors are encouraged to attend EH&S training for hazards faced by employees in their areas of responsibility. The class "HazCom Train-the-Trainer," for example, would apply to most work places.

6. Medical Exams and Vaccinations

WTC administrative staff- N/A

WTC lab staff- see appendix "B" attached to the back of this document.

D. DOCUMENTATION AND FOLLOW-UP

1. Record-Keeping

To meet State requirements, our department maintains records of safety activities for varying lengths of time depending upon the type of record, and is able to produce them when requested by EH&S or L&I. **Note: the EH&S Training office maintains records for EH&S classes. Call 206.543.7201 for more information.** Department records should include:

Results of self-evaluation inspections.
Records of requests for assistance in correcting noted deficiencies.
Minutes of safety education-accident prevention meetings.
Backup records of the above set are kept in labeled binders, on a bookcase, in the WTC facilities coordinator desk area.

Records of employees requiring medical evaluations including dates of examinations and immunizations.
Records of employee safety training, including dates when certificates expire, where applicable.
Backup records of the above set are kept in the MFL lab 135 by the WTC lab manager.

All records are on file with University of Washington EH&S. WTC has the right to elicit assistance from UW EH&S to procure records upon request.

2. Updates:

For this Plan to be useful as a "living document," it must reflect the department's *current* safety program and its *current* responsible parties. Periodic updates, at least annually, are necessary to ensure this. The "Back Page" of this document provides a convenient place to look for the most recent revision date, the names of key safety personnel, and other information.

E. THE SAFE CAMPUS PLAN (NEW SECTION)

While there are specific regulatory requirements for hospitals and late night retail operations regarding workplace violence that don't apply to general University operations, we do recognize that individual attacks on faculty, staff and students can and have occurred due to domestic violence or workplace violence. As part of maintaining a healthy, safe working environment, the University has developed and administers one UW Violence in the Workplace Policy and Procedure through the Human Resource's Violence Prevention and Response Program. Information on the program/policies is published on the UW website at http://www.washington.edu/admin/hr/polproc/work-violence/index.html.

University services include nighttime safety escort services, counseling sessions, a dedicated assessment team, and informational materials and training, but services are not limited to these items.

All managers, supervisors, and employees must be aware of the appropriate processes to follow regarding workplace and domestic violence prevention. They can receive assistance in answering any employee questions from the HR Violence Prevention and Response Program Manager. We expect our entire faculty and staff to take Workplace Violence training at least once every biennium, as well as receive information during new employee orientation. We arrange for the biennial training [fill in the method used by your work group]. Records of the training are maintained in the [give location] Office.

For more comprehensive information, access the SafeCampus website at http://www.washington.edu/safecampus.
If any staff has concerns regarding a threat of violence, call:

Seattle: 206-685 SAFE (206-685-7233)
Bothell: 425-352-SAFE (425-352-7233)
Tacoma: 253-692-SAFE (253-692-7233)

In a life threatening situation or imminent danger call 911, immediately!

"Back Page"

1. Department: Washington Technology Center (WTC)

2. Today's date / signature: 01 February 2011 __*pamela thomas*

3. Last update (date/person): 23 April 2010

3. Health and Safety Coordinator for our department: (from _2010 to 2012):
Name __Pamela Thomas
Phone _206-221-7132
E-mail pst@watechcenter.org
Bldg./Room/Box # ___Fluke Hall/ #310 / BOX 352140

4. Health and Safety Team members in our department:
For WTC lab: Mike Hjelmstad- MFL lab room 125 & 115B2

5. Organizational Safety & Health Committee:
Group #9, Helath & Safety Committee
Organizational Safety & Health Committee:

6. Group #9, Health & Safety Committee Elected: Name/e-mail/phone ___N/A__(from 2010 to 2012)

Appointed: Name/e-mail/phone Pamela Thomas pst@watechcenter.org 206-221-7132(from 2010 to2012)

Union Representative: Name/e-mail/phone__N/A ___(from 2010 to 2012)

Chair: Name/e-mail/phone _Ron Fouty 206-221-3350__(from 2010 to 2012)

University-Wide Safety & Health Committee representative for above Gr. #9: Name/e-mail/phone __Jack Herndon 206-543-2547__(from 2010 to 2012)

7. First-Aid/CPR Certified employees in our department:
Name/Phone/Expiration Date Pamela Thomas/ 206-221-7132 / Dec 2, 2011

Person responsible for stocking First-Aid Kits (UW APS 10.5):
Pamela Thomas for WTC Administrative, 3rd Floor
Mike Hjelmstad for WTC MFL Lab 135/ 115B2

8. Important Non Emergency Phone Numbers: WTC main line: 206-685-1920
WTC reception: 206-685-1922
See EH&S web-site at www.ehs.washington.edu
Click on "Service Phone Numbers"

WTC Quick Reference Sheet

Fire/ Chemical Emergencies

- In case of fire and chemical emergencies, call pull the nearest fire alarms, call 911, tell them if you are on the UW Campus and follow the Emergency Evacuation Plan

  Refer to Lab Manual for chemical emergencies

Other Facility Emergencies

- Call FOMS 206-685-1411
- Notify WTC Facilities Manager

Accident/ Injury Reporting

- For medical emergencies, call 911
- Report all accidents and injuries to the WTC Facility Manager. The Facility Manager will then request your assistance to fill out information on the OARS online report and perform follow through according to respective requirements.
- Accidents/ Injuries requiring medical assistance must be reported to EH&S within 8 hours. If no one is available to assist you in the OARS reporting, call EH&S at 206-543-7262. Refer to the web link for Accident and Incident reporting here for further assistance: http://www.ehs.washington.edu/ohsoars/index.shtm
- Non medical accident/ injuries must be reported within 24 hours

Work Place Violence

- Call 206-685-SAFE
- File Online Accident Reporting System (OARS) if injured

Motor Vehicle Accidents

- Motor Pool Vehicles: see Fleet Services
- If an Employee is injured, report using Online Accident Reporting System (OARS)

Other - Helpful Links:

- UW EH&S: http://www.ehs.washington.edu/
- University of Washington Medical Center
- Harborview Medical Center
- University of Washington Campuses - Hall Health Center

APPENDIX A: SMALL UTIITY VEHICLES & GOLF CART PROCEDURES

A. Small Utility Vehicle and Golf Cart Procedures

The Washington Technology Center DOES NOT allow the use of golf carts under any circumstances.

The following information is provided for visitors and guests of the WTC to build awareness for training issues to follow up with from their rental agent should they wish to use golf carts on their own time, under their own risk and responsibility.

These procedures are provided to facilitate safe operation of small utility vehicles and golf carts used during UW operations. Because these vehicles are typically of lighter construction, feature less safety equipment, and operate in different environments than typical motor vehicles, it is imperative that operators understand the particular capabilities and limitations of these vehicles, and that they are aware and take precautions against the particular hazards they may be exposed to.

Each department that operates these types of vehicles must adhere with the requirements of this procedure and should have trained staff members who are responsible for supervising operators. Since this procedure may not identify all hazards associated with particular vehicle operations, each department is responsible for conducting a "job hazard analysis" to determine the potential hazards for their specific operations and operating conditions (for example, crowded stadiums, steep slopes, or severe weather) and to take appropriate action to mitigate any particular hazards identified in that analysis. Departments are also responsible for ensuring that vehicles are maintained in a condition that allows for safe operation.

This procedure is for small utility vehicles and golf carts only, and is not intended for typical automobiles, trucks, or vans, or for riding lawnmowers, tractors, etc. This procedure does not replace or invalidate any other requirements or rules governing use of UW vehicles or equipment.

1. Definitions:
    a. Golf Cart: Small motorized vehicle with room for a driver, one or more seated passengers, and a small amount of equipment, generally not licensed for street use.
    b. Small Utility Vehicle: Small motorized vehicle designed for a specific type of work, such as a Cushman, a John Deere Gator or Kawasaki Mule, etc. These vehicles are mainly intended for off-street use, although they may be licensed for street usage. They are generally designed to carry equipment and/or passengers.
    c. Street Legal: A small utility vehicle or golf cart that meets the requirements of the State of Washington to be able to be driven on public roads according to the appropriate RCW and WAC sections and has been approved for such use by the manufacturer.

d. Trained Staff Member: UW employee who has been received training on the elements of this procedure and who is authorized by their department to supervise golf cart and/or small utility vehicle operations.

2. All drivers of utility vehicles or golf carts must attend a training session prior to operating any such vehicles, and must be a trained staff member or under the supervision of a trained staff member while operating vehicles. The training program should include:
    - The contents of this procedure, especially including all safety rules.
    - Safe operating rules of the road.
    - Precautions for operating in low-light or dark conditions.
    - Designated paths and routes for vehicle operation.
    - Procedures for unusual operating conditions, for example, while using an attached snow plow or towing, as applicable.
    - Limitations and restrictions on the use of the golf cart.
    - The difference between street legal and non-street legal golf cart/small utility vehicle.
    - Steps to be taken in an emergency.

3. All drivers must be 18 years of age or older and must have a valid driver's license. A copy of the current valid driver's license should be on file with the responsible department prior to operating the vehicle. Each department should designate an HR representative to keep this confidential information on file.

4. Utility vehicles and golf carts shall observe all vehicle traffic laws (e.g. stopping at stop signs, yielding to pedestrians, etc).

5. Vehicles shall not be operated in a manner that may endanger passengers, other members of the campus community, or property. Drivers must not be under the influence of alcohol or drugs. Drivers should not use radios or cell phones while the vehicle is moving. Absolutely no horseplay while operating vehicles.

6. The number of passengers and load capacity shall not exceed the manufacturer's rated limit. Passengers must be in seats. Seatbelts must be worn, if installed. Safety equipment, especially including seatbelts, may not be removed from the vehicle.

7. Driver and passengers must hold on to the utility vehicle or golf cart at all times while the vehicle is in motion unless securely seat-belted in place. Luggage, packages, cargo, and/or equipment must be adequately secured for safety.

8. Operators must operate vehicles at a safe speed for conditions, and should not operate vehicles at maximum speed.

9. Utility vehicles and golf cart-type vehicles that are not licensed for street usage are restricted to sidewalks and paths on the University campus. Street-legal vehicles may be operated on streets with prior approval of responsible department. Small utility vehicles and golf carts must be operated in accordance with all applicable traffic laws, particularly regarding usage of seat-belts and prohibitions against use of cell phones or texting while driving.

10. Check path of utility vehicles or golf carts and identify areas of caution or reduced speeds over designated paths. Drivers should slow when approaching such areas, or if traveling over paths which have not been assessed. Included in training session will be instructions on which paths to use.

11. Operators must reduce speed to match other users on all streets, sidewalks, and paths. In congested pedestrian areas, operators must either park or proceed at a slow walking pace.

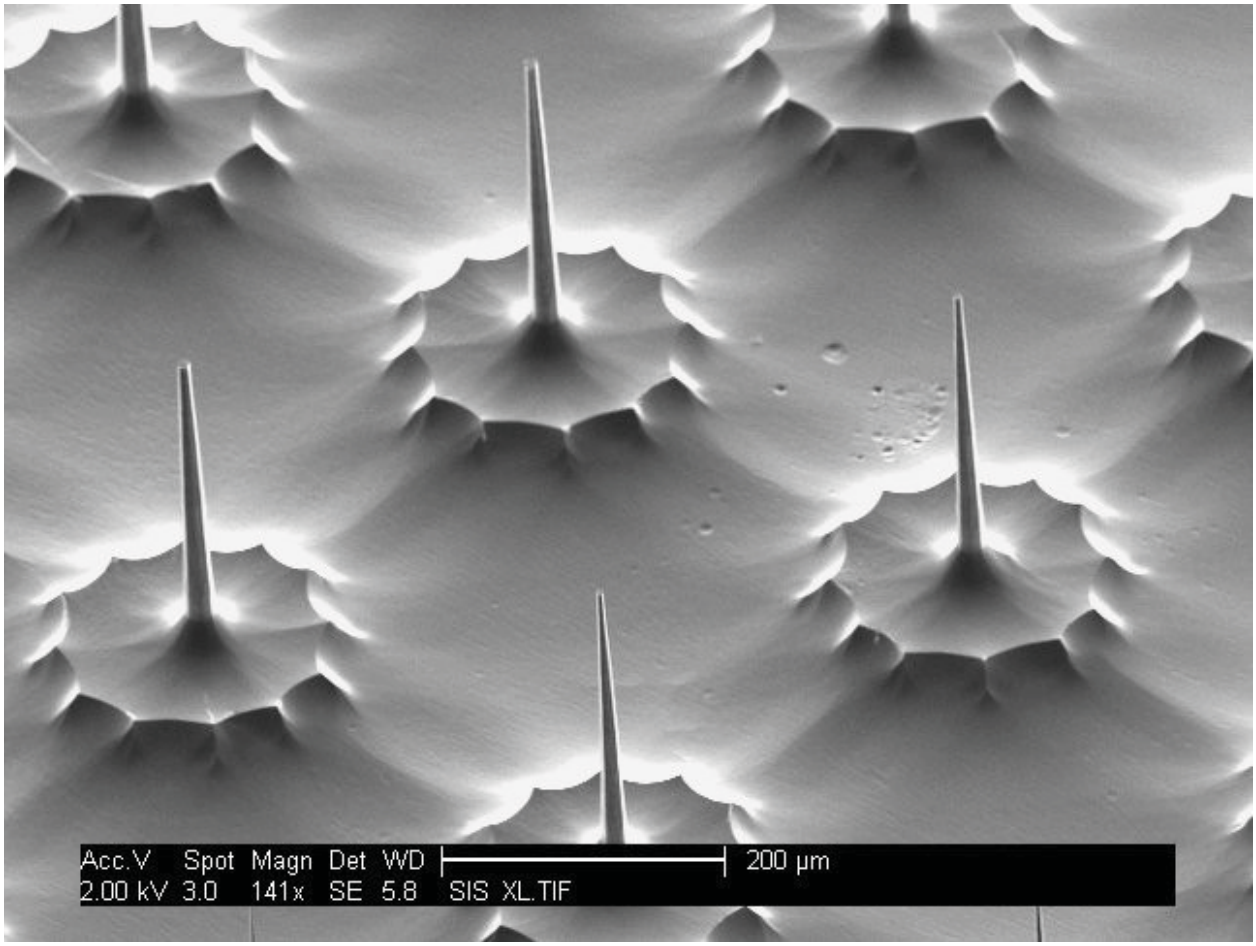
12. Vehicles can only be parked in a safe manner and location and must not block any entrances to buildings, stairways, ramps, or thoroughfares. Passengers who are not UW employees should be embarked and disembarked only when the vehicle is parked on a hard, level surface.

13. Charging stations for electric golf carts and utility vehicles shall be located in a safe location that has adequate ventilation to prevent potential build-up of explosive hydrogen gas, and which is adequately protected from weather.

14. Report all work-related injuries or near miss incidents to supervisor as soon as possible. Incident report instructions: http://www.ehs.washington.edu/ohsoars/index.shtm. Traffic and vehicle accidents may also require additional reporting to UWPD, Washington State Patrol, and/or Washington Department of Transportation.

APPENDIX B: MFL USER MANUAL

WASHINGTON TECHNOLOGY CENTER
ideas. connections. jobs
MICROFABRICATION LABORATORY



Adapted from: Y. Hanein, C.G.J. Schabmueller, G. Holman, P. Lücke, D.D. Denton, and K.F. Böhringer, "High-aspect ratio submicrometer needles for intracellular applications", *J. Micromech. Microeng.*, **13**, S91 (2003). Research performed at Washington Technology Center.

Washington Technology Center
Microfabrication Laboratory
User Manual

October 2010

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1.0 LAB MANUAL GOALS

This manual is dedicated to serve the better good of the Washington Technology Center (WTC) Microfabrication Laboratory facility and its users. Details in this manual serve as strict guidelines that must be followed at all times to ensure a safe and effective working environment for everyone. This manual by no means contains every detail users need to be successful, but highlights several key items that should guide users appropriately.

This document will be a living document and require changes as rules or policies become invalid or outdated. Users will always be given a two week notice on major changes to the manual before they will take effect. New users will be asked to complete an examination at the end of their orientation period that tests their understanding of this manual.

The WTC mission is that of economic development. WTC seeks to provide a facility for both academic users and industrial users. This synergy creates the need for a very strict and specific operating policy. The goal is to provide an environment that allows all users to be successful. This is likely to lead to a more strict policy than some users may be accustomed but will ultimately benefit all.

The lab manual seeks to achieve five significant goals:

1. **Articulate the potential dangers of working in the Microfabrication Lab and clarify the appropriate response to any emergencies.**
2. **Clarify the process of becoming a lab user. The initial steps, training, and various access levels.**
3. **List all important chemical safety items and how to work with and dispose of all lab chemicals in a safe and effective manner.**
4. **Review the fundamentals of working in a cleanroom and the protocol that is expected of all users within the Microfabrication Lab.**
5. **Document procedures for violations and disciplinary actions**

The WTC lab staff exists to maintain the facility and help users achieve their goals within the lab. We wish you the best of luck with your work.

2.0 INTRODUCTION

Washington Technology Center (WTC) is home to the 15,000 sq. ft. Microfabrication Laboratory located in Fluke Hall on the University of Washington, Seattle campus. This facility offers advanced microfabrication and characterization capabilities in 8,000 sq. ft. of clean room space.

WTC is a state chartered organization tasked to promote technology-based economic development. Key to this goal is promoting industry-university collaboration, thus the Microfabrication Laboratory is available to industry and academic researchers alike for research, technology and process development, and prototype manufacturing projects. The lab is also available to perform contract processing for users lacking the time or proximity to use the lab effectively.

The lab operates on two different access levels. Standard user access is from 9:00am to 6:00pm, Monday through Friday, during which time staff is available. Users can request after-hours access which would allow them into the facility between 5:00am and 12:00am seven days a week. The details of this process are in section 8.9.

The lab supports the processing of microelectromechanical systems (MEMS), microfluidic, micro-optic, and sensor devices. The lab is best suited to 100mm diameter substrates, with most applications also available at 3" and 150mm diameter substrates. Processing is divided into six major groups as follows:

Photolithography

- Spinners
- Contact Aligners
- Wet Chemical Processing

Nanolithography

- E-beam Lithography
- Dip-Pen Nanolithography
- Nanoimprinting

High Temperature

- LPCVD (SiN_x and SiO_2)
- PECVD
- Thermal Oxidation
- Rapid Thermal Annealing

Deposition

- E-beam Evaporation
- Sputtering
- Electroplating (Gold and Copper)

Etching

- Fluorine-based Reactive Ion Etching (RIE)
- Chlorine-based RIE
- Deep RIE (Bosch and Cryo)
- Wet Etch (metals and dielectrics)

Metrology

- Contact profilers
- Non-contact profilers
- Scanning Electron Microscopy
- Four-Point Probe

Back-End

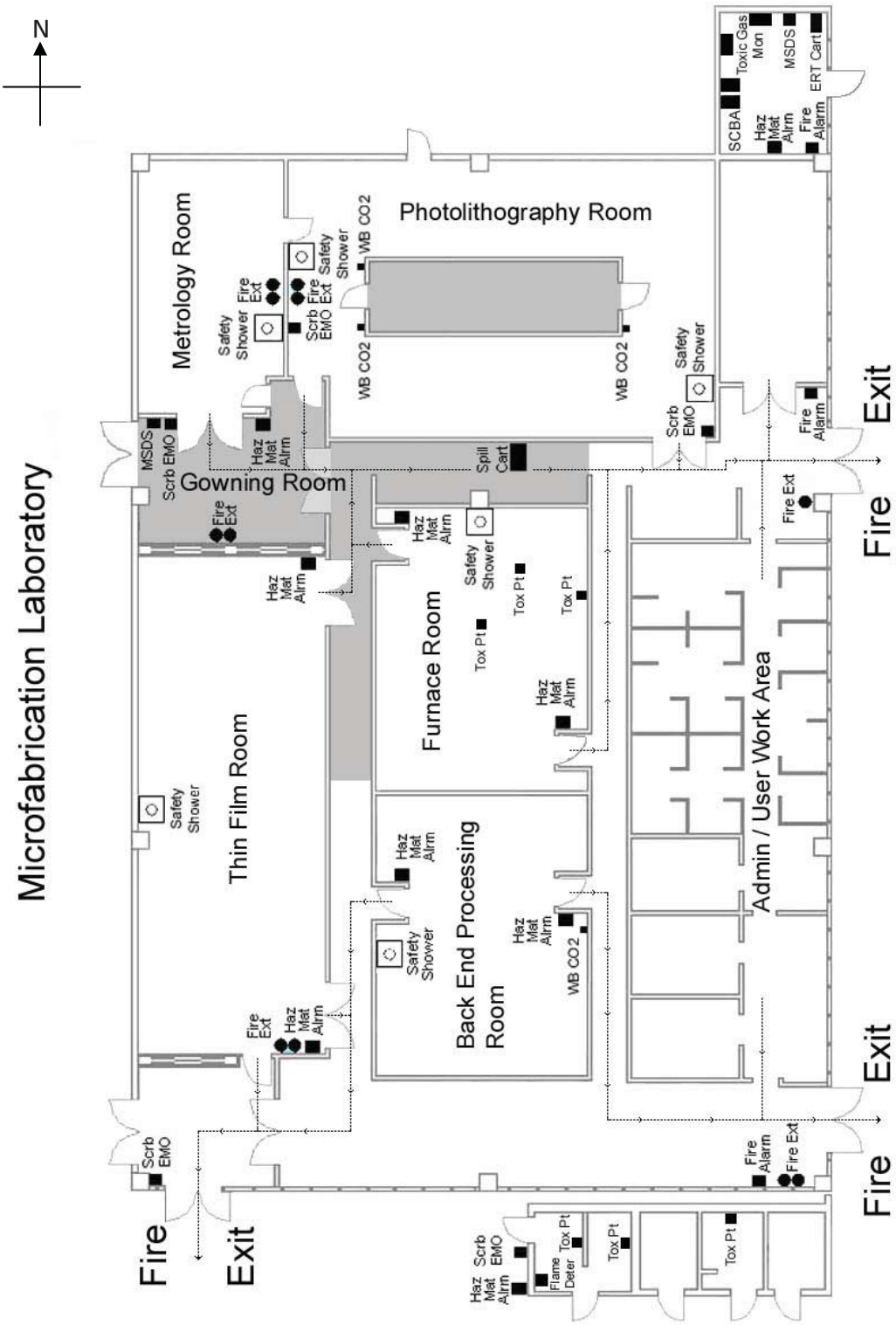
- Wafer Dicing
- Wafer Bonding
- Wire Bonding
- CO_2 Laser
- Screen printer

3.0 CONTACTS

Laboratory Staff	**Email**	**Phone*** **
Mike Hjelmstad Lab Manager	mhjelm@watechcenter.org	616-3855
Kevin Kerkof Staff Engineer	kkerkof@watechcenter.org	616-6981
Paul Schilling Staff Engineer	pschilling@watechcenter.org	616-5725
Sergei Goloborodov Process Technician	sergeig@watechcenter.org	221-2669
Josiah Ward Lab Student Assistant	jward@watechcenter.org	616-7321
Environmental Health & Safety (EH&S)		
Chemical Spills, Exposure, Odors		543-7262
Building/Facilities		
Microfabrication Lab (Cleanroom only)		616-1930
Pamela Thomas Fluke Hall Building Coordinator		221-7132
U.W. Physical Plant		685-8814
Emergency/After Hours		
Police (Emergency)		9-911
University Police (Non-emergency)		543-9331
Lab Manager (After Hours)		(425) 894-6243
Facilities Emergency (UW Physical Plant)		685-1411

*** All contact numbers are (206) area code unless noted. All UW numbers can be reached by dialing only the last 5 digits from a campus phone.

4.0 LAB LAYOUT



5.0 EMERGENCY

5.1. Expectations

While the goal of the lab is zero emergencies, work in the facility creates the potential for emergency situations on a regular basis. This manual and all policies are designed around safety and minimizing any potential for emergency. Users creating an elevated risk for emergencies will be warned or removed from the lab. All users are expected to respond to any emergency they encounter with the conditional exception of chemical spills (explained further in sections 5.8). WTC staff expects that any user encountering a fire, hazardous material (HAZMAT), or medical emergency will respond as required in this chapter and notify staff as soon as possible. Once staff is notified of an emergency they will take command of the incident.

5.2. Medical Emergencies

Any medical emergency should be dealt with by phone. Since the lab is on the University infrastructure this means dialing 9-911. Signs are posted by every phone for reminder and every room except metrology has a phone. Any medical emergency should be immediately followed with a call to staff informing them of the situation. If no staff is available, the lab manager should be called at the after-hours number on the phone list.

5.3. Fire and HAZMAT Alarms

The Fire and HAZMAT alarms are linked directly to the Seattle Fire Dept. and will trigger their emergency response. Fire alarms can be signaled using any of the RED pull boxes located in each room. A fire alarm will trigger sirens in all areas of the lab and office space. In most areas at least one ceiling strobe light labeled Fire will be activated. HAZMAT alarms are signaled using any of the YELLOW pull boxes located in each room. A HAZMAT alarm will trigger a short signal followed by a voice that will instruct everyone in the building to relocate to the building lobby. Chemical spills should be treated as HAZMAT situations if the spill exceeds 1 gallon. Under 1 gallon the chemicals should be disposed of according to guidelines in section 10.11. Staff will respond to either alarm by assisting the Seattle Fire Dept. from a facility-knowledge basis. Users should follow the procedure outlined below:

Fire (RED Pull Box)

Users should not attempt to subdue a large fire or one that seems to be spreading faster than it can be knocked down. In that event, pull one of the RED fire alarm boxes and immediately evacuate the building. Exit routes are described in section 5.4 and illustrated on the layout in section 4.0.

Hazardous Material (HAZMAT) (YELLOW Pull Box)

WTC takes significant precautions to keep users from creating a HAZMAT situation. WTC also relies on its users to understand the dangers of chemicals and gases they are working with. Users should pull one of the YELLOW HAZMAT alarm boxes if they believe there is an immediate danger to anyone in the lab. If they feel unsure about the danger, they should find another user to immediately contact staff for an assessment, while keeping other users out of the area.

In the event of a HAZMAT alarm, all building occupants are required to rally to the building lobby on the north side of Fluke Hall on the first floor. The building lobby is designated as a central point where emergency responders can meet people and make any further evacuation if needed.

5.4. Exit Routes

Section 4.0 illustrates the Microfabrication Laboratory floor plan and has arrows indicating the proper emergency exits routes. In the event of a fire or HAZMAT alarm do not degown (unless contaminated, then follow decontamination instructions of emergency personnel or staff); immediately proceed to the proper location. Realize that for a HAZMAT alarm, users do not necessarily need to leave the building, but must relocate to the building lobby on the north side of the building. Please realize that if a HAZMAT alarm is active, users should still relocate to the building lobby on the north side of the building. There are 3 emergency exits from the facility: the northeast and southeast doors lead to the parking lot adjacent to Mason Rd. The southwest door leads to the loading dock and out to another parking lot. Please follow these routes depending on your location.

- Metrology, Photolithography, and High-Temperature rooms should exit to the grey area containing the lab tools. Exit through the chase and straight out through the northeast door and into the parking lot.
- Thin Film room can exit according to the metrology, photolithography, and high-temperature rooms, or exit through the door at the south end of the room and out the southwest door to the loading dock, whichever is closer.
- Back-End processing room should exit through the southeast door into the parking lot.
- Office space should exit through the northeast or southeast door, whichever is closer, and into the parking lot.

If you leave the building in your cleanroom attire, please degown outside and allow staff to recollect the materials for proper laundering.

5.5. Fire Suppression

There are several fire extinguishers located around the lab in the event of a small fire. You'll always find extinguishers in pairs: one silver can, the other red. Silver cans are filled with water and should only be used on fires involving flammable solids. Red cans are filled with CO_2 and should be used on chemical or electrical fires.

In addition to fire extinguishers, several wet benches have built-in fire suppression systems using CO_2. In the lithography room, the hot plate bench containing the gold-plating bath, the CEE spinner bench, solvent bench, and KOH processing benches have suppression. This system is activated by a fire in the bench or by switches located at opposite ends of the chase dividing the photolithography room. The wet bench in the back-end processing room and the wet bench in the thin film room containing the copper-plating bath also have suppression systems that can be activated at the specific bench and are not linked to others.

5.6. Facilities Emergency

Facilities emergencies would involve the lab or building infrastructure and are responded to by the University of Washington Physical Plant. Examples of appropriate facilities emergencies would include ruptured facility pipes (N_2, CDA, vacuum, water) or a HVAC failure. Anything that occurs with specific lab equipment or within wet benches is the responsibility of WTC, and does not warrant a call to UW Physical Plant. Please contact staff if an emergency occurs during regular hours, and they will follow-up with UW. If the emergency occurs after hours, the emergency facilities line at UW is 685-1411, or on a UW line just 5-1411. Any call to facilities emergency should be followed by a call to the lab manager regardless of the time.

5.7. Chemical Emergency

Chemical emergencies can often be avoided by proper handling and the use of appropriate personal protective equipment. However, due to the high usage of chemicals in the lab, a chemical emergency is probably the greatest risk to users. The solvents in the lab do not present a health danger on contact and have a far greater flammability risk. Strong acids or bases require the greatest care when handling as they can cause burns or tissue damage. If a chemical comes into contact with a small area of skin, immediately remove clothing from the contact area and flush skin with water for 15 minutes. If chemicals come into contact with the eyes, eyewash stations are located in each room of the lab. Users should hold their eyes open in the eyewash for 15 minutes while rotating their eyes. For large scale exposures, showers are located in each room directly above the eyewash station. Users will need to remove clothing to flush the contact area. No curtains are available at shower stations so please do not be modest as your health may depend on proper flushing of the exposed area. Users are required to inform WTC staff if they have had an exposure to a dangerous chemical. If a hospital visit is

needed, it is always valuable to take the material safety data sheet (MSDS) for the chemical to the hospital as the proper medical care can be better determined with the MSDS (refer to section 10.4 or locations).

Hydrofluoric Acid (HF)

Hydrofluoric Acid (HF) is the most dangerous chemical in the WTC Microfabrication Lab. As little as 100mL is potentially lethal if untreated. HF will not cause a contact burn when exposed to human skin. Rather it is absorbed into the body and does not show any sign of exposure until it begins to break down the calcium in bones. The acid can move through the body causing lowered blood calcium, destruction of bone, and ultimately cardiac arrest if untreated. Users should immediately flush the exposed area with water for at least 5min. Remove any contaminated clothing and dispose of it properly (rely on someone else for this). After flushing the exposed area apply HF antidote cream located at bench 3 (where the HF bath is located). The HF antidote is 2.5% calcium gluconate gel; the gel will bind with the fluorine ions and diminish any long term damage. The affected individual should go directly to the hospital ER or have an ambulance called. The calcium gluconate should be reapplied every 15min until medical personnel are on-site. If you are aiding anyone experiencing HF exposure consider your own safety and wear black, neoprene gloves which offer the highest protection from HF. If HF exposure is to the eyes, do NOT use calcium gluconate in the eyes. Instead flush eyes for 15min using the eye wash. University of Washington EH&S provides excellent in-depth details on HF exposure in a document that can be found at http://www.ehs.washington.edu/manuals/tips/hydrofluoricacid.pdf

5.8. Spill Response/Personal Protective Equipment

A spill cart is located in the tool grey area for any chemical spill that is not considered a HAZMAT emergency. Users must contact staff for any emergency involving the spill cart, and are strongly recommended to simply have staff respond to the spill emergency. The spill cart will contain acid and base neutralizers, HF spill kits, mercury spill kits, caution tape for clearing an area, and personal protective equipment. Personal protective equipment includes the latex and neoprene acid gloves, aprons, and face shields that are outlined in section 10.6. Additionally HAZMAT level B suits are available on the spill cart for staff use only.

5.9. Emergency Manual Off (EMO)

Most pieces of equipment in the lab have an EMO switch which will disable all power to the system. This is not an advisable method of shutting down any system, but is a quick one-step solution for an emergency. If a user sees any kind of electrical arcing, smells or sees smoke, or hears an odd sound they should not hesitate to use the EMO switch. Since an EMO can be hard

on equipment, users are asked to carefully distinguish process instabilities and uncommon runs from emergency situations. Flickering plasma, unusual etch rates, or a system that will not pump down to the expected vacuum are not emergencies. They should be dealt with as uncommon runs and approached as described in section 8.6.

5.10. Electrical Shunt Trips

Shunt trips are electrical shutoffs for entire busses. One shunt trip can disable multiple pieces of equipment connected to a single buss. The majority of equipment in the photolithography lab is connected to shunt trips. The design is for safety, especially in a fire emergency. Tripping several breakers at once quickly reduces the risk of fire ignition from an electrical source. Any power failures to the facility will also set off the shunt trips. If a shunt is tripped it must be reset manually by staff before power to its components can be restored.

5.11. Compressed Gases

There are several compressed gases used at WTC that can trigger a potential emergency situation, and many safety measures are in place to avoid just that. The lab uses two pyrophoric gases (silane and dichlorosilane) and four potentially corrosive gases (ammonia, chlorine, boron trichloride, and silicon tetrachloride) which are all located outside the building in the concrete bunkers. Silane and dichlorosilane are pyrophoric gases meaning they will ignite in contact with air. Improper handling of these gases has caused fatal accidents at other facilities. Ammonia is a corrosive gas and is also kept in its own distinct bunker. Silane, dichlorosilane, and ammonia are used in the chemical vapor deposition (CVD) systems to deposit amorphous silicon, SiO_2, and SiN_x. Chlorine-based gases are toxic and potentially corrosive with exposure to water. For all hazardous gases, the cylinders are contained in their own special gas cabinet with a nitrogen purge bottle for proper cylinder changing. Users are not permitted access to the gas bunker under any circumstance. The WTC maintains monitoring equipment to detect any of the above gases. Any detection of the gases will trigger a HAZMAT alarm. WTC staff maintains all compressed gas cylinders with assistance from Airgas. Only WTC or Airgas personnel are allowed to disconnect or move gas cylinders. Users in need of any cylinders or bottle changes must contact WTC staff.

6.0 GETTING ACCESS AND GENERAL PROTOCOL

6.1. General Disclaimers

There are a few disclaimers not printed in the current user agreement that need to be stated for safety and legal interests. Any disclaimers specific to equipment are explained in section 8.4. The following are specific notices users should consider that are not included in the standard user agreements.

- Pregnant Women – If female users are pregnant or intending to become pregnant they should not work in the photolithography area. Exposure to chemicals in photoresists has been shown to cause birth defects in mice. The exposure does not appear to affect long term reproductive health if used properly.
- Intellectual Property (IP) – The lab user agreement specifically states WTC policy regarding IP. Non-disclosure agreements (NDA) are also possible between WTC and clients if necessary. However, since the lab is open to all users, users are responsible for keeping their IP private. The lab is not responsible for any IP lost by users due to their own errors or carelessness. Please consider this if you have any significant IP. The lab will try to make arrangements whenever possible to provide secure locations for products or work.
- At-risk Work Area – The lab is an at-risk area. It is precisely this reason that all users are required to follow the rules outlined in this manual to reduce as much risk as possible. Regardless, this is not a guaranteed-safe work area, so please be constantly aware of your surroundings and potential risks. If at any time you become aware of an unsafe working condition in the lab including equipment, facilities, or other lab users, you are required to report the issue to the lab staff so appropriate action can be taken.

6.2. Hours of Operation

Staff is on site from 9:00 a.m. until 6:00 p.m., Monday through Friday. Staff follows University of Washington guidelines for holidays. Equipment involving toxic gases (silane, dichlorosilane, ammonia, silicon tetrachloride, boron trichloride, and chlorine) may only be operated when staff is present (typically 8:00am until 6:00pm, Monday through Friday). The lab will be available to users on two different access levels:

Standard Access

Standard access grants users entry to the MFL facilities through rooms 125 and 135 in Fluke Hall, Monday through Friday, from 9:00am until 6:00pm. Standard access allows staff to be more observant of users and it is aimed at new users, especially those with

limited or no prior cleanroom experience. The standard access will also serve as a probationary period for users seeking privileged access.

Privileged Access

Privileged access grants users access to the facilities from 24 hrs/day, seven days a week, including holidays. Privileged access is reserved for users who have demonstrated an exemplary record of working within all rules and regulations within the lab facilities as determined by the lab staff. They must understand the off-hours policies and be aware of their expanded responsibilities in these areas. The process of obtaining privileged access is described in section 8.9.

6.3. Granting Access

The following steps are followed, in order, to become a user of the WTC Microfabrication Laboratory.

1. New or interested users should visit the lab website, www.watechcenter.org/lab to see the upcoming training schedule.
2. Register for the lab orientation and wet chemistry/CORAL training by e-mailing the lab manager at MFL_Manager@watechcenter.org (or see the contacts list in section 3). The orientation is typically held on the last Monday of the month at 9:30am.
3. Orientation will be held in the Bowen room on the first floor of Fluke Hall in the main lobby. Orientation will review the major points of this manual and provide users with a tour of the lab facility.
4. After attending the orientation session, wet chemistry training, and the CORAL training. WTC staff will verify that a facilities use agreement is in place for the user's principal investigator (academic) or company (industrial). If no agreement is in place the user will be contacted by WTC to arrange such an agreement. Academic users will be asked to have a form signed by their advisor allowing access on their budget; the form will be provided during orientation.
5. An orientation exam will be scheduled by the user with staff. Users are recommended to complete the wet chemistry training class which reviews all of section 9 before taking the examination. Questions will be directly from this manual, the bulk coming from sections 5.0, 6.0, 8.0, 9.0, and 10.0.
6. Once a facilities use agreement is in place and the user has passed the orientation exam, users are issued a key card to access the laboratory (University of Washington students and staff will use their Husky Card). A $50 deposit is required for key cards issued to non-University of Washington users. The key card may be used only by the person to

whom it is issued. Contact the lab manager concerning lost or forgotten key cards. Key cards must be returned when laboratory use is terminated.

7. Users should determine their process and equipment requirements and begin signing up for training classes for specific equipment as close as possible to the time they will actually require it. Specific questions about training should be directed to the training contact listed on the information page on the web site for a given tool. The training process is outlined in section 8.1.

6.4. Access Card

The white access card (industrial users) or Husky card (academic users) is your identification card within the facility. The entire lab is a secured facility with access permitted via your identification card. Your access level (standard or privileged) is encoded within the card. White cards require a $50 deposit. If users lose a card, a loaner card can be issued by the lab manager for a maximum of 48 hours. Replacement white cards can be made by WTC for the $50 deposit fee. Cards that have failed due to regular wear and tear will be replaced, but require the user to return the original card. Husky cards can only be replaced by UW.

6.5. Terminating Access

Users and their company or principal investigator (PI) are responsible for informing WTC of access termination. A written document delivered via e-mail, fax, or mail is required to terminate access for a user. If a user changes his/her company or PI without informing WTC, the prior company or PI is responsible for the charges incurred. Thus, it is critical that PIs or companies maintain an accurate list of their users.

6.6. User Fees/Billing

As of October 1, 2010 the billing structure at the Microfabrication Lab will change to focus on an equipment usage bill structure. The structure is designed to charge users for actual equipment usage while still allowing a discount to heavy users. There are three distinct charges while working in the Microfabrication Lab.

Access Card Fee

For each active card users are charged $100/month for each user. This is effectively a membership fee to the lab to guarantee access as needed. The fee is charged even if the card is active for only one day in the month. It is a user's responsibility to request activation/deactivation based on their needs.

Daily Entry Fee

Users are charged $50/day for entry to the lab. This fee covers access to any of the equipment that is not interlocked in CORAL. A hard cap is put in place on this fee to

prevent regular users from paying an excessive amount. Industrial users are capped at $600/month per user. Academic users are capped at $200/month per user.

Equipment Usage Fee

Each piece of equipment that is interlocked in CORAL has a specific hourly usage fee associated with it. The enabling and disabling action within the CORAL software (see section 7.6) is the start and end time for billing. Hourly rates are based on other user facilities similar to the Microfabrication Lab as well as the cost of ownership for the equipment. The rates are posted on the lab website and are up for review periodically. There is a threshold value when equipment rates become reduced. This value is currently $3600/mo per user for industrial users, and $1250/mo per user for academic users. The threshold will change the hourly rates to only 15% of the regular rate.

7.0 CORAL

Common Object Representation for Advanced Laboratories (CORAL) is a hardware and software system that controls user access to the equipment within the Microfabrication Lab. The hardware aspect involves small interlock relays at each piece of equipment. The interlock is installed in such a way that the system cannot operate without it turned on, but at the same time is in a safe, stable state when the interlock is off. The systems that are interlocked in CORAL are identified in Appendix C.

The software aspect of CORAL is the only interface users will have with the system. The software interface will allow users to reserve time on the equipment, enable and disable the interlocks for each system, and report any errors or problems with the equipment. Billing information as well as equipment certifications are stored within CORAL as well.

7.1. Login

The CORAL software runs using Java Runtime Environment. Users should open their web browser to coral.watechcenter.org. The page will open a window that allows users to link to the latest update of Java Runtime, or Launch CORAL. The first time users launch CORAL a shortcut will be placed on the user desktop that can subsequently be used to access CORAL. All computers in the lab have this shortcut called “CORAL Remote”. Upon starting the computer will ask users to login to the system. Users will receive login IDs and their passwords during the CORAL training for new users.

7.2. CORAL Clients

CORAL has two separate clients users will interface: the equipment client and the resource client. The resource client is a database interface tool that contains billing info and equipment certifications. The equipment client will be used for reservations, interlock switching, and reporting problems. Users will likely spend >95% of all their CORAL time on the equipment client. The equipment client is the default client that opens once users are logged in.

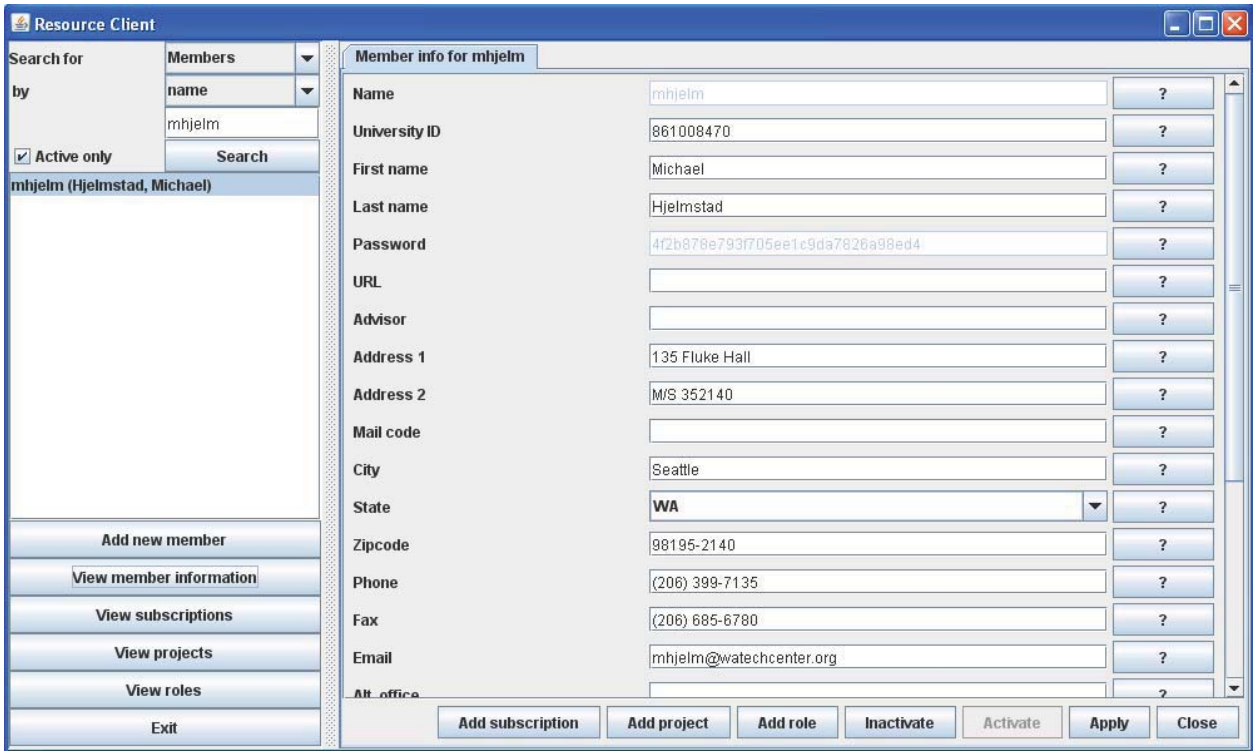
7.3. Resource Client

The resource client is access by clicking “Window” then “Resource”. The window is essentially a search query that allows you to search by various important components described below:

- Members – Members are the actual lab users. They are individuals, typical members are referred to by a username which is usually the same as their e-mail address prefix.
- Projects – Projects are the actual work category that members work under. These are typical UW budget numbers or specific products for the industrial users. Members can work for one or more projects depending on need.

- Accounts – Accounts are the top level in the user hierarchy and it is either the company itself or the research group for academic users. All projects and members are tagged back to a specific account.
- Roles – Roles define the permissions of members in CORAL. For example, staff has a "lab:staff" role that allows them to certify users and operate any piece of equipment. Users can only obtain one role "equipment:user" which indicates they are authorized to use a specific piece of equipment.
- Services – Services are regular monthly subscriptions that members may have. This could include a regular charge for office space. At this point the Services within CORAL are not used.

Users are required to maintain their member information and make sure their roles are accurate. To maintain member information, search by member for your username. The results should appear below the search bar. Highlight the search result and click "View Member Information to bring up the following window:

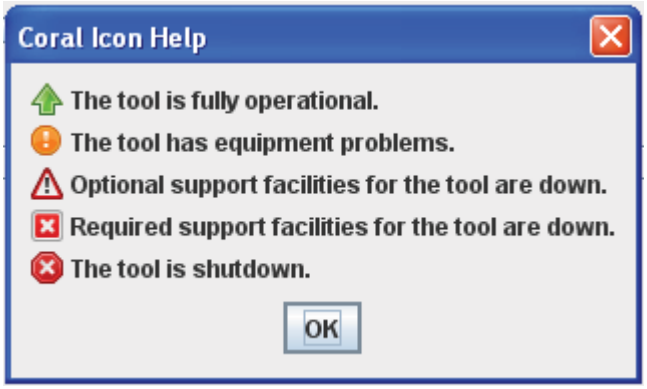


Users are required to maintain all information. This information is meant to be business only, please do not add any personal information as others will have access to this. A valid phone number is required, as well as a valid e-mail address. Without a valid e-mail address in CORAL, the user may not receive key e-mails from the lab.

Users should also regularly search their name for information on their roles. On the same screen shown above, users can click "View Roles" to see all of their equipment certifications. If there are any problems, the user should contact the equipment owner/trainer for clarification.

7.4. Equipment Status

When looking at specific equipment in the tree of the equipment client, users will find the equipment in one of 3 major states: operational, problem, or shutdown. They will be indicated by different icons. To clarify the icon meanings, users should click "Help", "Icon Help" and a listing of the various icons will be explained.

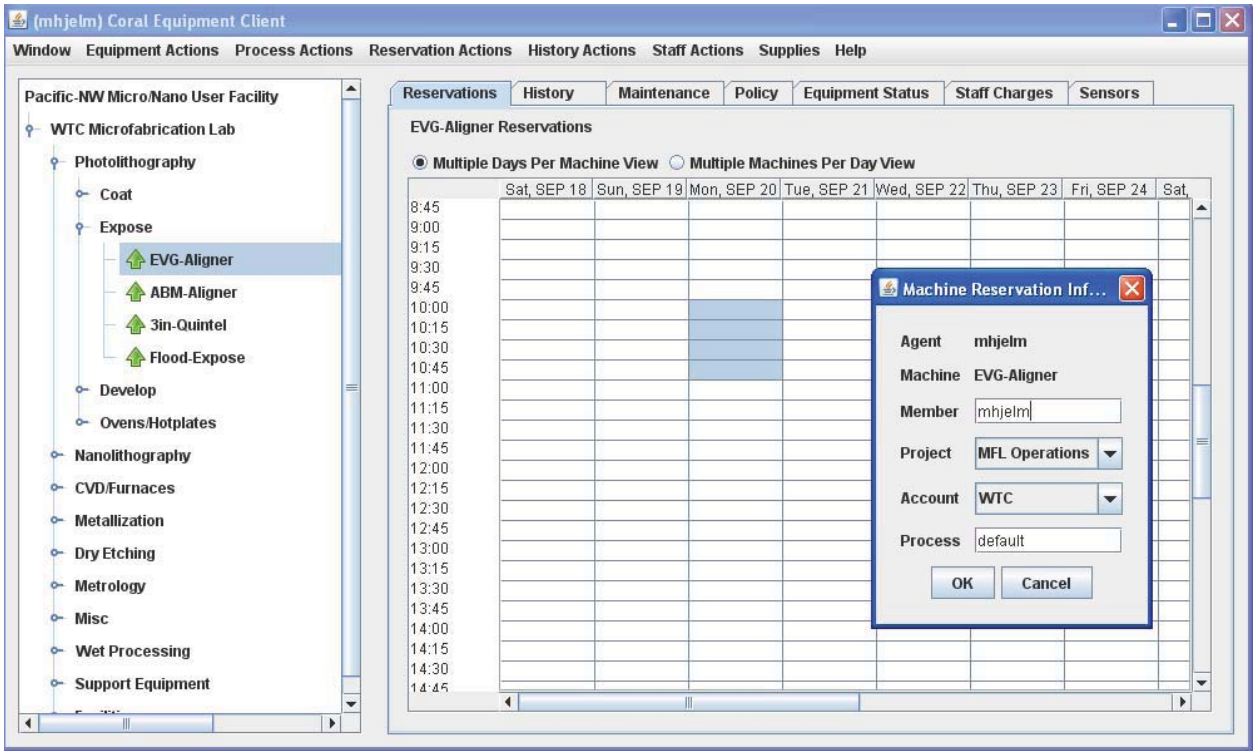


The equipment status of multiple systems can be ascertained by clicking on an appropriate heading. Clicking on "WTC Microfabrication Lab", and then selecting the tab labeled "Equipment Status" will display all enabled system in the lab by default. Selecting the appropriate checkboxes will give the user the opportunity to determine all problems or shutdowns within the lab. To determine individual equipment status and the sources of problems or shutdowns, find the appropriate equipment in the tree directory. Select the equipment, then click on the "Maintenance" tab. The default view shows any unresolved items for the past three months. Users can change the date involved, or they can click "Show Message" to seen the full description behind the shutdown, problem, or comment.

7.5. Making Equipment Reservations

Equipment reservations in CORAL are used as placeholders and users are not charged for making any reservations. The rules regarding equipment reservations are described in section 8.5. To make the reservations in CORAL users need to start on the equipment client, then select the appropriate equipment from the tree structure at the left of the screen. On the right side of the screen be sure the "Reservations" tab is selected. The screen will now show a grid of all time slots on the equipment for the next 2 weeks. Go to the desired start time, click and drag the mouse over the course of the reservation. Remember that the times are in 24:00 format, and that the times listed represent the beginning of the block. After selecting your

block, click “Reservation Actions” then click “Make”. A window, as seen below, will come up that verifies the user logged in, as well as the account and project the user is planning to use.



Click “Ok” and the reservation is made. The member name will now fill the slots and make the tool unavailable during that time (though the interlock could still be enabled by anybody). To delete a reservation, click on the reservation, then click “Reservation Actions” followed by “Delete” to remove the reservation.

7.6. Enabling and Disabling Equipment

Enabling equipment will start the equipment usage fee associated with each tool. Make sure you are present in the lab and ready to use the equipment prior to enabling it. To enable the equipment find the appropriate equipment in the tree structure at the right. To enable the system, users must have certification which is denoted by an asterisk following the equipment name. Secondly, the system must be operational, or in a problem state to allow enabling. Click on the equipment, then click “Equipment Actions” followed by “Enable”. A dialog box opens again to ask user which account and project to bill the work against. Click “Ok” when completed. The system is shown as enabled when a member name appears next to the equipment name in parentheses. To disable the interlock, click on the equipment with your name shown enabled, click “Equipment Actions” followed by “Disable”. **NEVER DISABLE A PIECE OF EQUIPMENT ENABLED BY ANOTHER USER**. This could have a catastrophic effect on the system. Please contact staff if a user has a system enabled, but is not present.

7.7. Reporting Shutdowns or Problems

Processes fail and equipment does malfunction, it is a fact of working in the Microfabrication Lab. One of the most important goals of the lab is to minimize equipment and facility downtime. Users can help ensure this by reporting any shutdowns or problems to staff as soon as possible using CORAL. To do this properly, users need to have a sense of what constitutes a shutdown, problem, or a comment.

- Shutdown – A shutdown occurs when a flaw disables the machine from running in any circumstances. This would include things like a vacuum failure, mechanical failure, or anything else that prevents a user from moving through the full SOP as intended.
- Problem – A problem is less severe than a full shutdown. Problems do not always prevent a user from completing a run on the system. If the system fails to meet a process specification, or a component on system doesn't work (e.g. a heater on a sputter system that does not always require the heater).
- Comment – A comment is something not preventing the equipment from running properly, but important enough to inform staff. For example, equipment left dirty or a process improvement recommendation.

Users should make their best judgment deciding which of the 3 situations to log. To log the equipment, users need to find the piece of equipment in the tree on the left side of the equipment client. Once highlighted, click "Equipment Actions" and then decide amongst "Shutdown", "Report Problem", and "Make Comment". A window will appear that requires a subject line, as well as a body paragraph. This window will become an e-mail to all certified users for that equipment. Try to make the subject line short and to the point. After that provide as much detail as possible within the body paragraph to inform staff what exactly happened to the equipment. Staff will contact the user if necessary. Any reported shutdown, problem, or comment requires a resolution by staff before the CORAL status will change.

7.8. CORAL Errors and Alterations

Honest and legitimate user errors are expected to occur within the CORAL system from time-to-time. If this happens, users may request an alteration to the CORAL log to reflect proper usage. The CORAL Alteration Form in Appendix H (also on website) should be used for any such request, available on the lab website. The user should identify the mistake and request a proper beginning and end time for their true usage. Staff is committed to reading and deciding all alteration requests within 24 hours of receipt. The final result will be sent back to the user for record-keeping.

For overnight runs, please review the rules regarding overnight runs in Section 8.7. As long as other users can remove wafers and are unaffected, an edit to the CORAL database can be made to reflect the endtime of the actual process. The requests MUST be made before the end of the month. For runs that last into the following month, the request must be made by the end of the day on the 1st of the month.

7.9. CORAL Rules

There are four significant rules that must be followed at all times with CORAL:

1. Users may not enable a system for any other user. The name displayed next to the system is considered the responsible user. If the individual does not match the member name on CORAL, both users will be ejected from the laboratory immediately and could constitute a permanent ban.
2. Users are not allowed to use another members CORAL login. Users must be diligent about exiting the CORAL remote software when finished. Conversely, users are not allowed to take advantage of an open CORAL window to get their work done. Failure to follow this rule will result in expulsion of the guilty user.
3. Users must complete runs they begin and are not allowed to pass work to another user. The exception would be if a piece of equipment fails and requires a shutdown or problem notice in CORAL (staff would consider a CORAL log and disabling of the system a proper completion). In emergencies, staff can be contacted to finish equipment runs and properly shutdown the system.
4. Users must swipe their card and open the door to room 125 individually. Piggy-backing another user is not allowed and will be viewed as a user trying to circumvent the rules. Users have made honest mistakes in this regard, and lab staff will warn users before enacting any serious penalties.

7.10. Penalties for CORAL Violations

Failure to follow the main CORAL rules outline above in section 7.8 will result in very serious penalties. The system is setup to force users to login and logout for all equipment activities, and require a conscious decision to violate rules #1 or #2. There is a sense of fraud associated with the violation of these rules and it is the most severe violation within the lab. As a result, users caught in violation to rules #1 or #2 will be subject to immediate expulsion from the laboratory, and suspension of their equipment and access authorizations. Investigation by staff will either lead to a significant suspension or a permanent expulsion from the lab.

Rules #3 and #4 are considered less severe than rules #1 and #2. Violations of these rules could be seen as accidental on first offense. Users in violation will be warned of their mistakes before serious action will be taken. Subsequent violations of either rule #3 or #4 will be treated in the

same manner as a moderate violation as described in section 11.2. If a third violation of either rule arises it will be treated as a severe violation and the user will be expelled from the laboratory.

8.0 EQUIPMENT USE

8.1. Training

Training for each piece of equipment in the lab involves two sessions, an instruction session and a follow-up certification of the user. In the first session, instruction is provided by a staff member for one or more users. The instruction usually includes the following: An introduction to the system; a description of process capabilities and allowed materials; safety features and precautions; an overview of system components; full operation of the system following the standard operating procedure (SOP) with detailed descriptions of each step and a conclusion informing the trainees of their responsibilities for the second session.

For the second session, the user will attend one of the scheduled follow-up certification sessions for a one-on-one with the instructor on the equipment. In this session, it is the user's responsibility to demonstrate their full understanding of the system and to operate the equipment in accordance with the SOP and all guidelines set forth in the instruction session.

If the user is able to complete the follow-up to the satisfaction of the instructor, they will gain the equipment certification and gain access to the tool in accordance with the facility and equipment use policies.

Plan ahead; trainings are available for sign up by the 25th of the previous month. It is extremely difficult for staff to provide training on days other than scheduled. However, extraordinary circumstances can arise that require special training classes. In this case, users can schedule, with the trainer, a special training class at a rate of $200/hr. Please show patience for the training process; users should never expect an immediate training and follow up just because they are in a unique situation requiring work ASAP. Requirements for each training step are as follows:

1. Individual equipment will have a training class scheduled on a monthly basis. The schedule will be on the lab web site. Users should sign-up for the training class by sending an e-mail to the instructor listed on the website. Users are required to bring a copy of the standard operating procedure (SOP) for the specific equipment to training. Users are expected to take notes on the process and should bring all notes to their follow-up session. The SOP of any tool can be found by following the *Tool Bench* link on the lab web site and then selecting the specific tool. Users may be denied training if they do not arrive with a SOP. Lower-use tools will not have a regularly scheduled training. Users interested in training on these tools should contact the training contact listed on the web site. Due to multiple conflicts in the past, the process run during this

stage of the training is a standardized one selected by WTC staff. Staff will not run a user's process unless it is a special session paid for by the user.

2. The follow-up session must take place within a month of stage 1 otherwise the user will be asked to repeat the initial training. Users should bring their copy of the SOP and any notes to the follow-up. In addition, users must run an expected process during their follow-up session (no random examples). Users will need to provide their own materials (substrates, etc.). Users who arrive for follow-ups without a SOP, valid process, or materials may be denied a follow-up chance that day. Users are expected to prove their understanding of the process and procedure. They will execute the process as needed without help from the trainer. The trainer will decide whether or not a user has passed a follow-up. With a passing mark, the user gains the equipment certification for that tool (see section 8.2). If a user fails a follow-up session, the user can retry, but must wait for a 48 hr period as a penalty.

8.2. Equipment Certification

Equipment certification is granted by completing the training follow-up session successfully. With an equipment certification the user is allowed unsupervised access to the equipment during their allowed lab access times. Equipment certifications are posted within CORAL and can be accessed by following the directions in section 7.3. Within the equipment client in CORAL, an asterisk following an equipment name also indicates a proper equipment certification.

8.3. Certification Lapse and Retraining

If six months elapses from a user's last use of a piece of equipment, the lab staff will consider their certification lapsed. This lapse can be calculated using CORAL and will be updated by the staff member responsible for each piece of equipment. While their certification is not completely revoked, they will not be allowed to use the equipment until they have been retrained. Retraining for certification lapse will be stage 2 of the training process described in section 8.1.

8.4. Equipment Expectation

WTC seeks to provide the highest degree of equipment uptime and working processes; however, users need to have reasonable expectations of what is possible.

- Processing – The ultimate goal of processing is to have 1-4 core standard recipes on each piece of equipment. At the date of this revision only a few systems have working standards (e.g. thermal oxidation, DRIE). The staff will continue to develop the standards over the next year. Outside of the core standards, WTC cannot guarantee any

other processes in the lab. Staff expects to run regular tests to ensure the proper function of equipment by using the standards.

- Downtime – Staff will work to minimize downtime. The order for which down equipment are attended to is the decision of WTC staff with a strong slant toward higher-use equipment. Staff seeks to have a cumulative equipment uptime of at least 90%, and a facilities uptime of at least 95%.
- Preventative Maintenance (PM) – PM procedures are outlined for 20 pieces of equipment, and are located on the bookshelf in the lab office area for public viewing. Users are welcomed to make requests for other pieces of equipment, but it is the sole decision of WTC staff.
- Process Changes – Any process changes will be relayed to the users that have certifications for the given equipment. It is not expected that tools will have significant process changes and they will be relayed via CORAL e-mail.
- Limited Process Times – Equipment using the toxic gases can only be used when staff is present in the facility regardless of the user access level.

8.5. Equipment Reservations

All equipment reservations are made via CORAL as described in section 7.5. Equipment scheduling is tied directly into certifications; thus, reservations are impossible without the proper certification. Rules regarding reservations are as follows:

- Reservations are given a 15-minute late grace period on the starting time, unless a prior reservation interferes with the start time.
- Users working without a reservation must yield the equipment to anyone with a proper reservation.
- There is a 15 minute grace period on finishing times. If users are consistently running beyond their reservation time they will be warned and possibly lose their certification.
- Users should delete any reservations they cannot fulfill as soon as possible.
- If users must sign up for equipment for an extended period of time (greater than 6 hrs) it is asked that they allow for breaks if other users have short (less than 30 min) runs that need completion. Try not to be a time hog. It is beneficial if breaks can be made in the reservation to show users that there is some availability.
- Keep reservations accurate. Do not reserve a 4-hour time block for 15 minutes of required work. Users attempting this may have their certification revoked.
- If work is completed before the end of the reservation, please delete the remaining reservation via the web site so other users are made aware of the added availability.

8.6. Equipment Malfunction/Uncommon Runs

If users experience any equipment usage that is in conflict with their training, or if a piece of equipment is left in a damaged state prior to their usage, they MUST report it to staff according to the following protocol. Following this protocol will allow for proper refunding on equipment usage if appropriate.

- Use CORAL to mark a problem or shutdown for the equipment according to the directions in section 7.7
- Place a "Down for Repair" sign on the equipment. These signs can be found in the tool chest in the tool grey area. This ensures that if any of the other 2 items are missed by other users, there is a notice at the machine indicating it is not useable.
- Write a note on the whiteboard in the gowning room stating the date, which tool is down, and write your name for reference. Users are only taking responsibility for informing others, and notification is not considered a mark of guilt.

8.7. Overnight Runs

For extended processes such as furnace runs, wafer bonding, or e-beam lithography exposures it is often appropriate to setup the system in a safe and effective manner and allow the equipment to run in the late hours. In runs where the system can be left in a safe state (staff equipment owner's discretion) the user can leave the system logged in on CORAL and leave the lab. The user can disable the system the next morning when retrieving their samples. The user should fill out the CORAL alteration request (see Appendix H) to recover the appropriate billing time. If a user seeks a CORAL alteration, the user must either retrieve their samples the next morning prior to any other user run, or leave notice to the next user allowing them to remove any samples. Failure to remove samples may result in a user being billed for the entire time their samples were in the system.

8.8. Consumables from WTC

Some consumables are supplied by WTC as part of the existing user fees. These materials are those likely to be used by several other users such as chemicals, non-precious metals, and some types of photoresist. WTC also stocks items that are available to users as added-cost items such as silicon wafers, wafer handling tools, and precious metals. A clarification of which materials are part of the user charges and which are considered extra is covered in Appendix E. WTC will consider adding items to the "free" supply list if it is deemed valuable for many users. The decision will be made by the lab manager.

Precious Metals

Precious metals at the WTC are gold and platinum used in either e-beam evaporator. Due to the significant and rapidly increasing cost of these materials an extra cost is associated with usage. Users are welcome to supply their own material and appropriate crucible; WTC staff can point users to the appropriate vendor. Due to the very high initial expense of filling a crucible, WTC keeps a filled crucible in stock for immediate use. The crucible is weighed before and after use and the user is charged for the difference. The charges are compiled and applied at the end of each month with access fees. Mass used is rounded to the nearest 0.1g for this process.

8.9. Privileged Access

After-hours and weekend use of the facility is strictly reserved for privileged users only. Privileged users are those which the staff deems knowledgeable and trustworthy enough to be safe without staff presence. Users should realize that the more interaction with the staff, the better staff will have an understanding of the user's traits, positive or negative. Privileged access is granted only by under unanimous staff support of the user.

9.0 CLEANROOM POLICIES AND PROCEDURES

9.1. Shared Facility

The WTC Microfabrication Laboratory is a user facility shared between several industrial users and academic users. A shared facility can create several inherent problems unless users are always conscious of and respect other users. Consider the fact that everything you do in the lab can affect other people's work and it should be the ultimate goal of every user to minimize any impact they may have on other users' work. Section 9.0 targets specific policies and procedures that will serve this goal. Being considerate about lab and process cleanliness, reporting any equipment problems immediately, and informing staff of potential policy violations will better serve the lab community as a whole.

9.2. Cleanroom Operation

The cleanroom at the Microfabrication Laboratory is certified class 10,000, which is considered to be cleaner than the standards of a hospital operating room. To create cleaner air the WTC has high-efficiency particulate attenuation (HEPA) filters in the ceiling throughout the cleanroom. Lab air enters through the HEPA filters into the cleanroom and exits through recirculators or under wall gaps in some rooms. The specifics of cleanroom operation are detailed in Appendix B. Special cleanroom gowns are required while in the lab. When users enter the lab they go through the gowning procedure described in section 9.5. The cleanroom attire must be worn in every area of the lab except the back-end processing room which has no direct access from the cleanroom. Adjacent to some cleanroom spaces are grey areas where cleanroom attire and regular street attire are acceptable. These areas are reviewed in section 9.8.

9.3. Lab Cleanliness

Users must assume primary responsibility for the lab housekeeping. Staff will work to make sure all facilities are in place to maintain the cleanroom and strive to improve capabilities when possible. Users need to:

- Leave wet benches dry and organized when complete.
- Throw away all used wipes or other waste in the correct waste container when finished.
- Clean up all minor spills immediately, or contact staff for major spills.
- Aspirate or dispose of properly, all chemicals poured up by the user when finished.
- Dispose of all garbage immediately. Do not leave broken wafers lying around, do not leave tape on table edges, do not leave wipes around new or used.

Failure to follow simple housekeeping rules will constitute a safety violation. Good housekeeping will result in a safe environment for all users and give the user strong reputation for doing good work. **REMEMBER: the lab is a community of users. What you do can and will affect other users positively or negatively.**

ATTITUDE towards cleanliness will ultimately determine the success or failure of any cleanroom policy. All the elaborate equipment providing a microscopically clean or controlled atmosphere would be without value if users do not believe in and help enforce these policies. When in the cleanroom, be aware of your knowledge limitations! It is extremely important that you ask questions if you are unsure about the operation of the facility or any equipment. If you know your limitations and ask good questions, you will gain respect among the community as one who realizes that one stupid mistake can cause a great deal of damage.

9.4. Restrictions

For safety reasons, open-toed shoes, sandals, and shorts are prohibited from the laboratory because they do not provide any protection from potential chemical spills. The use of contact lenses in the lab is strongly discouraged, as chemicals can become trapped between your eye and the lens.

The following materials are prohibited from the cleanroom to prevent particulate contamination:

- Food and Drink
- Cardboard
- Packing Media (this includes FedEx/UPS boxes or envelopes)
- Pencils

Cardboard containers may be used in the lab service chases to allow transport of materials, however, users are encouraged to use plastic tubs that can be brought into the cleanroom to store their supplies while they work. Non-cleanroom paper is allowed, although discouraged. Cleanroom notebooks may be purchased from the WTC staff.

9.5. Cleanroom Gowning Procedure

Access to the cleanroom requires specific attire to minimize contamination. Users should realize that within a cleanroom of this type the goal is not to protect yourself from the chemicals or processes used within, but to protect your work from contamination that is easily transferred by humans (hair, skin oils, water vapor from respiration). Should any of the required garments not be available, please contact staff immediately. The gowning protocol at

WTC is the same one would find for a class 100 cleanroom and should be performed in the following order (all 7 items are mandatory):

1. **Shoe Covers**
   Shoe covers are blue or white with elastic bands to cuff around the ankle. They are found in the dispenser to the immediate left as you enter the gowning room. Completely cover your shoes with the shoe covers.
2. **Hairnet**
   Hair nets are found on the shelves neighboring the center hanger rack. All hair must be contained in the hairnet to be effective
3. **Facemask**
   There are three types of facemasks. The first is a disposable mask similar to a surgical facemask and is found in the dispenser with the shoe covers. These masks have a wire that is designed to pinch around the nose. Another disposable mask is available and snaps into the inside of the hoods. The last facemask is a launderable type that snaps into the inside of the hoods. The latter two are located on the shelves with the hairnets. Any of the three types is acceptable.
4. **Hood**
   Hoods are found on the shelves with the facemasks with four sizes from which to choose. When determining whether the hood is inside-out, the sewn edges as well as the tag should be inside. The snaps at the base of the skull should face outward and can be used to tighten the hood. The snaps at the temples should be on the inside of the hood and are intended for the snap-on facemasks.
5. **Smock**
   Smocks are kept immediately below the hoods on the shelves with sizes ranging from small to 3XL. Height is often a determining factor of proper smock fit so a larger size is recommended when first trying out sizes. The hood 'skirting' should tuck underneath the smock.
6. **Boots**
   Once the smock is on correctly you can proceed to the other side of the plastic divider. The bench on the other side has several pairs of boots under the bench. These are community boots and range from small to XL. Choose the correct size; the snaps should clasp behind your calf and the strap should go over the top of your shoes. The boots go over the end of the smock.
7. **Gloves**
   Gloves are in the dispenser when immediately entering the lab or on the table next to the computer near the boot bench. Gloves are nitrile and have some minor acid resistance to them, but should not be used in place of acid gloves.

Upon completing work in the cleanroom, garments should be removed in reverse order. The boots should be placed sole to sole, wrapped with the legging, and put back under the bench in the appropriate location (by size). The smocks and hoods can be put onto hangers in the appropriate location, please see the Laundry section for specific details. Gloves, facemasks, hairnets, and shoe covers are disposable and should be thrown out (with the exception of the specifically launderable facemasks).

9.6. Laundry

Smocks, hoods, and launderable facemasks should be cleaned on a regular basis. Aramark Laundry Services picks up the laundry every Tuesday morning and returns last week's cleaned laundry. Users who are regularly in the cleanroom at least 3 days per week can get a hanger for their smock and hood. Users receiving such a privilege are required to put their smock and hood into the hamper on Monday evening for the next pick-up. Other users should place their smocks on hangers on the visitor rack. The visitor rack is located to the right as you enter the gowning area against the wall between lockers. Hoods should be placed on the top of the rack for other visitors to use. Since each user should be using a hairnet, the concern of hygienic contamination is minimal and not of significant concern. Staff removes the smocks and hoods from the visitor rack once a week on Tuesday morning for pick-up.

9.7. Personal Hygiene

Personal hygiene can have a serious impact on lab cleanliness. Users with colds that include coughing, sneezing, runny nose, etc. can damage others' work in the lab. If you get sick, please refrain from using the lab until you are well again. WTC staff members may ask sick users to leave the facility if they feel the user poses a problem to other people's work or health.

9.8. Grey Areas

Grey areas are areas of the lab where cleanliness standards are not as strict to allow users a common area where cleanroom attire and street clothes are allowable. Grey areas are marked by plastic drapes, never cross two consecutive plastic drapes in either direction. These areas are ideally suited for support facilities for lab equipment such as pumps, gas bottles, etc. It allows staff to maintain these types of facilities without going through the full gowning procedure. The grey areas also serve as effective pass-throughs for materials entering or leaving the cleanroom. Optimally, chemicals are packaged in plastic bags within cardboard packaging materials. The proper procedure is to bring a plastic-bagged chemical bottle to the chase, remove it from the bag and bring it into the cleanroom. It creates a multiple stage effect where the cleanliness is raised slightly going into the chase, then significantly going into the cleanroom and minimizes large particulates in the wrong area. The grey area serves as an appropriate place to bring in wafers or specialty chemicals like photoresists. At WTC, two grey

areas exist: One is commonly referred to as the “tool chase” located between the high-temperature room and photolithography and is named as the lab’s tool set is located there. The other service chase is commonly referred to as the “gas bottle chase” located between the high-temperature room and the thin-film room and is named due to the majority of process gas cylinders housed in this area. While the cleanroom material restrictions do not apply to the grey areas, all users are expected to clean up any materials used in the grey area. Furthermore, the grey areas are absolutely not for storage of any kind, staff has full privileges to dispose of any materials left overnight without prior authorization.

9.9. Tools

The lab maintains a tool set of typical items such as wrenches, screwdrivers, etc. The tool set is located in the tool chase between the high-temperature and photolithography rooms. The tool set and lab support equipment will be available to all lab users under the following guidelines:

- All tools must be treated with care and used in a safe manner for their intended purpose only.
- All tools must be returned clean and undamaged to the drawer or storage area where they came from as soon as the project is completed or by the end of each work day.
- Tools and equipment may be signed out for extended use and/or use outside of the Microfabrication Laboratory by permission of any WTC lab staff member.
- All lost or damaged tools and equipment must be reported to lab staff as soon as possible. WTC will replace lost/broken tools except in cases of obvious negligence.
- Users are restricted from using any tools on any equipment unless it is specifically discussed or demonstrated during the equipment training sessions.
- Users must consider the cleanroom environment before starting any project in or out of the actual lab. Remember that the tools are intended for use within a cleanroom and need to be kept VERY clean.

These details are posted next to the tool chest. Lab users are required to use extra judgment in matching applications with the tools they use and considering the potential cleanroom impact. For example, the cordless drill could be used to drill holes in a piece of wood outside of the lab facility. If the drill and bit are not thoroughly cleaned before being returned, the sawdust can potentially be brought into the cleanroom and cause severe particulate contamination. This lack of additional thought can cost many users a successful device.

9.10. Compressed Gases

The Microfabrication Laboratory uses several compressed gases that are potentially dangerous. Inside the building the gas bottle service chase handles nearly all other compressed gases

ranging from specialty gases like SF_6 and C_4F_8 to common gases like He, O_2, and Ar. Most process gases located in the service chase serve equipment in the thin film room. SF_6 is a common etch gas for silicon and silicon nitride in reactive ion etching (RIE). The fluorocarbons, also referred to as Freon, are the etch gas for silicon oxide. Argon is typically used in sputtering systems as the gas source for the plasma due to inertness and high mass. Helium is used as a cooling gas for wafers usually in dry etching processing. Oxygen is used in to create plasmas that have an affinity for etching organics and are often considered cleaning plasmas. During trainings, WTC staff will identify which cylinders are associated with which equipment. Users should verify bottle pressures before operating equipment as routine, but it is WTC responsibility to ensure there is enough gas in the cylinders for users to complete their work. Cylinders are changed only by WTC staff or Airgas technicians. Toxic gases at WTC (including silane, dichlorosilane, ammonia, and chlorine-based gases) are extreme safety concerns and are covered in section 5.11.

The lab has two additional compressed gases: nitrogen, and air, that are part of the lab facilities infrastructure. Nitrogen is from the liquid nitrogen tank at the south side of the building. The nitrogen is evaporated and passes through heat exchangers eventually becoming compressed through stainless steel lines. The nitrogen serves nearly every tool in the lab, especially as a purge gas in the vacuum systems. Nitrogen jets are also available in most areas of the lab and serve as means to removing particulates or drying wafers with a clean, inert gas. Compressed air, often termed CDA for “compressed dry air” is supplied via a house compressor. The CDA serves almost exclusively for pneumatic controls on several pieces of equipment.

9.11. Cryogenics

Liquid nitrogen, with a boiling point of 77K, is the primary cryogen used at WTC. Liquid nitrogen can cause severe skin burns on contact. If liquid nitrogen is exposed to room temperature it will boil and evaporate very quickly causing rapid expansion of nitrogen gas which can displace oxygen and cause asphyxiation. Liquid nitrogen is therefore kept in dewars within the lab. Dewars are filled in a properly ventilated area with appropriate personal protective equipment, by WTC staff only.

9.12. Buddy System

The buddy system is required for after-hours usage (5-9am and 6pm-12am). The buddy system requires that at least two users must be inside the cleanroom at all times. During regular hours, staff is present and can serve as anyone’s “buddy”. THIS RULE IS TO ENSURE THE SAFETY OF ALL USERS. This is standard policy in nearly all cleanrooms and is a change in prior operating practice as of the date of the original document. Staff does check the lab after hours on occasion and takes this rule seriously.

9.13. Wafer Handling

New cleanroom users will be surprised at how significant wafer handling can be to their process. An appropriate example would be to speak to someone holding a wafer slightly in front of their face, or simply breathe on the wafer without a facemask for a minute. Viewing the wafer under a microscope will reveal the reason such care is taken in lab cleanliness and the gown-up requirements. Wafer handling recommendations include:

- NEVER sneeze, cough, or spit towards your wafers even with a mask on. Resulting spots are non-removable.
- Never speak towards your wafer
- Avoid passing anything over your wafer which may release particles (i.e., don't look directly down on your wafer; don't cover the wafer with your hand).
- Whenever possible, store wafers in covered containers. WTC recommends using the wafer box you received the wafers in, or purchasing single-wafer carriers from WTC staff.
- Use special handling tools like tweezers and tongs to handle or move wafers around.
- If you tear your gloves at anytime, immediately get a new pair from the glove box near the gowning room computer. This serves a cleanliness function and a safety function as the nitrile gloves have some chemical resistant properties.

9.14. Wafer Storage

Wafer storage is extremely limited at the Microfabrication Lab. The WTC will make a small area in the high-temperature room available to users needed wafer storage within the cleanroom. This area will be reassessed and cleaned of leftover wafers on a monthly basis. The goal of this policy is to encourage cleanliness of wafers by keeping items in the cleanroom during the user's project time. The storage area is NOT for long-term storage and is only for wafers in process.

Wafers left in non-storage areas will not be tolerated. If left out overnight, wafers may be immediately put into the lab lost-and-found or discarded. Any notes left on wafers will be disregarded and the wafers may be forfeited. It is the responsibility of the user to speak with staff regarding any needed exceptions. Ovens are NOT an appropriate place for storage. The main lithography ovens should never have wafers left beyond a few hours, and the vacuum ovens may occasionally hold wafers overnight when specifically called out in processing steps.

9.15. Desk Space

Desk space is also extremely limited at WTC. Desk space is prioritized for industrial users that are meeting the monthly billing cap on a regular basis. Academic users from universities other than UW could also potentially be given desk space (UW users are assumed to have appropriate

desk space on campus already). Desk space is a privilege that can be revoked by the lab manager at any time, with a two-week timeframe for property removal. Users are required to keep their areas clean as tour groups often come through the area with WTC or on-site users. It is staff discretion whether or not a user's desk is up to the cleanliness standard.

9.16. Internet Policy

Wireless Internet and direct Ethernet connections are available within the office space. Users with desks are permitted to connect to the Ethernet lines, and UW students or staff will be able to connect to the wireless connection as well. No external routers are allowed to be connected to either network. All users must follow the internet policies laid out by WTC or UW Technology. Information can be found at http://www.washington.edu/computing.

9.17. Locker Policy

Lockers in the gowning room are available to users and can be requested of the lab manager at any time. The lab manager will allow up to two lockers to each PI or company. The full locker policy is contained in Appendix F. Of critical importance is that absolutely no chemicals or any restricted materials may be contained in the lockers, and lockers cannot be locked so staff may enforce the policy.

9.18. Guest/Visitor Policy

Guests of individual users are welcome to the Microfabrication Laboratory anytime staff is present. Guests are not welcome to work directly on any piece of equipment but are welcome to observe trained staff using the equipment. Oftentimes the lab will be able to accommodate visitors to observe a specific process while they go through the training procedure for individual tools. This will allow new users to overlap with qualified users and learn a process they will work on. At the same time, they will learn proper usage of the equipment before actually having to run the equipment themselves. Any visitor to the lab must complete the visitor form in Appendix G and return it to the lab manager at least one day prior to any visitation.

10.0 CHEMICAL HANDLING/PROCESSING

10.1. Facilities

Several facilities exist for the user's benefit when working with chemicals. All facilities described are maintained by WTC staff, but require some understanding from users to make sure they continue working properly.

Acid Waste Neutralization (AWN)

The sink drains and aspirators at all acid/base benches drain to a neutralization tank where wastewater is neutralized before being drained into the city wastewater system. Specific details of the neutralization process are described in Appendix D. Users should consider the following details regarding the AWN:

- Aspirators should be used whenever first emptying a container as the system adds a significant amount of water to the solution to dilute it properly while in the drainage system.
- No solvents can go directly into the AWN system according to the city waste regulations. Solvent disposal is described in section 10.8.

Emergency Manual Off (EMO)

The lithography room is equipped with special EMO switches on the east and west walls. These EMO switches are linked to the electrical shunt trips specific to the lithography room. The shunt trips will disable electricity to all the equipment in the lithography room. The EMO exists because a solvent spill in the lithography room poses a significant fire hazard that could be triggered by an electrical short. Use an EMO switch in combination with any HAZMAT alarm.

Deionized (DI) Water

All faucets and spin/rinse dryers in the lithography room distribute deionized water. The specifics of the DI water system are described in Appendix C. The water leaves the system with a resistivity of 18.1 MΩ-cm. Any WTC documentation calling for solutions with H_2O implies DI water. DI water should also be used to thoroughly clean glassware after each use. The system goes through a sanitization twice each year for an entire day and WTC will suspend all chemistry in the lab for those days.

10.2. Reducing Waste/Chemical Usage

All users are strongly encouraged to reduce their waste and chemical usage as much as possible. The greater the waste, the greater the cost to WTC, which can translate into higher user fees to cover that cost. Use small dishes when using metal etchants or negative resist

developers. The same is true for lift-off solutions of acetone or hydrofluoric acid. Users are encouraged to only use large tanks for positive resist developers as they have a high usage among users and will last for at least an entire day.

10.3. Chemical Storage

WTC maintains supplies in four chemical storage cabinets. Two are found in the lithography lab: the yellow resist cabinet, and the blue developer cabinet. The other two are found behind the metrology room: the acid and base cabinet. The yellow resist cabinet contains all photoresists, acetone, isopropanol, and waste containers for solvents and strippers. The blue developer cabinet contains positive resist developers and photoresist strippers. The acid and base cabinets contain all pure acids and bases in addition to metal etchants. Users will be shown all storage cabinets during the Wet Chemical Processing training class.

10.4. Material Safety Data Sheets (MSDS)

Copies of all MSDS for lab chemicals are posted in the lab gowning area on the wall next to the computer. State of Washington law requires these to be updated and displayed as public information to all lab users. MSDS are created by the chemical manufacturer and will contain details on ingredients, physical characteristics, health hazards, among others. The sheets allow staff to determine where chemicals can be used, and how to properly dispose of them. The sheets also serve as crucial information for first aid or any potential fire or HAZMAT incident. All users are strongly encouraged to review the MSDS for chemicals they plan to use in the lab. Staff will review major safety issues with chemicals during the Wet Chemistry training class.

10.5. New Chemicals

A three-step procedure exists for any new chemical a user wishes to bring in to the lab. This policy is developed to work with state and federal laws, and to maintain a high level of safety in the lab. Therefore users not following this procedure will be subject to heavier disciplinary action than other offenses.

1. The user will request that a chemical be allowed in the lab and provide the lab manager with a copy of the MSDS. The specific process/application should also be provided to make sure a suitable alternative does not already exist. The request can be made in person or via e-mail.
2. Lab staff will review the chemical to determine if it is safe enough for use in the lab. Staff will determine the appropriate storage, working locations, and disposal method for the chemical. A yes/no answer and the expectations for the chemical will be relayed to the user within 48 hours via e-mail.

3. Users can bring in the chemical to the lab and follow the staff guidelines for the chemical. The user is asked to inform staff when the chemical is no longer being used.

10.6. Personal Protective Equipment

Personal protective equipment (PPE) is critical when working with chemicals and can prevent severe injury or even death. There are three types of PPE that are required from users when working with strong acids or bases: apron, gloves, and face shield. All three are located on the hangers in the northwest corner of the photolithography room near the door to metrology. There are latex (orange) gloves that offer good protection against the common acids in the lab. Neoprene (black) gloves are also available and are the best protection against hydrofluoric acid exposure. It is recommended that acid aprons be put on first, then gloves over the apron. Turn the ends of the glove inside out to create about a 1 inch cuff; this will prevent any chemicals from wicking around the end of the glove and into contact with skin. If any piece of PPE is damage or does not seem safe as deemed by the user, please discard it in the trash and obtain a replacement. Immediate replacements are always available next to the refrigerator in the grey area behind the EVG aligner in Photolithography. There is a box labeled *Personal Protective Equipment* which contains a back up of each PPE item in every size. Users are welcome to take from this stock but MUST notify staff so a replacement can be purchased.

10.7. Wafer Cassettes

There are three different wafer cassettes that users will find in the lab. Two should be used mainly for storage purposes, while the other is specifically for chemistry only.

- Clear cassettes labeled “WTC” – These are chemically resistant cassettes and should be used for all chemical processing. These cassettes fit into the appropriate diameter spin rinse/dryer. Handles for the cassettes are available throughout the lab. These cassettes are not for storage under any circumstance.
- Blue cassettes or clear, unlabeled cassettes are specifically meant for temporary storage within the lab. These cassettes have some chemical resistance, but not as significant as the labeled cassettes. The thermal properties are not as significant either. While these cassettes are for storage they are not truly meant for long-term storage.

10.8. Solvents

Common lab solvents are acetone, 2-propanol, SU-8 developer, and ethanol. These chemicals typically have very low boiling points, and are highly flammable. Solvents are only allowed at the stainless steel solvent bench in the southeast corner of the photolithography lab. Staff will demonstrate the disposal and clean-up procedures during Wet Chemical Processing training.

Disposal

The flammability of these chemicals requires special disposal policies. Acetone and isopropanol have a distinct waste carboy that is housed on the bottom shelf of the yellow photoresist cabinet. SU-8 developer also has a separate one gallon waste container that is kept in the waste cabinets near the double doors that lead out of the photolithography room to the office space. Any other solvents must also be removed from the lab in properly labeled waste containers; absolutely no solvent should go down the drains into the AWN system. Once a chemical is disposed of properly the glassware can be cleaned up.

Clean Up

Any spills can be wiped up using the cleanroom wipes located around the lab. Any waste containing solvents or photoresists must be thrown away in the vented garbage can. Any glassware that contained solvents should be cleaned as follows:

1. Wipe down the entire surface of the glassware with a wipe that is wet with isopropanol.
2. Move to the other side of the lab to the sink at bench 1 and rinse out the glassware with DI water from the sprayer or tap. The minor amount of isopropanol residue is okay to rinse down the drain into the AWN system.
3. Add a small squirt of soap from the bottle located at that bench. Add some water to clean and rinse thoroughly with water.
4. Leave the rinsed out glassware on the drying rack located at that bench. Staff will return clean dishes to the glassware shelves when dry.

10.9. Acids/Bases

Pure acids and bases are clearly labeled as such and nearly every metal etchant is a solution of some strong acid or base. Please review the Chemical Use standard operating procedure (SOP) if there is any confusion. Acids and bases can only be used at the polypropylene wet benches on the north side of the photolithography lab.

Disposal

WTC facilities are configured so that users may dump acids or bases down the drain at the appropriate wet benches. The drain goes into the AWN system where the chemicals are neutralized before being delivered to the city wastewater. Aspirators should be used whenever possible as this will significantly dilute the liquid being disposed. This is very important as concentrated acids being poured down a drain could create a potential explosion hazard. Nearly all acid or base solutions can be aspirated at the wet benches, and a list of which solutions can be aspirated appears at every bench in the

lab. To use the aspirator, simply put the tube in the solution, then step on the pedal located under the bench. It is not possible to aspirate the entire solution, as the vacuum will not allow small puddles to be drawn into the aspirator. The remainder can be disposed of down the drain by rinsing the glassware with water. The end of the aspirator should also be sprayed down with DI water to remove any remnants of the disposed solution.

Clean Up

Any acid or base spill can be neutralized using the appropriate neutralizer found on the spill cart. Also, users should feel free to dilute any spill on a wet bench by spraying a significant amount of DI water onto the spill. Any overflow at the acid/base wet benches goes directly into the AWN system. Squeegees can be found at all the wet benches where they can be used to direct any liquid into the sink drains. Leave all wet benches dry when finished to avoid any chemical (visually, HF and water are identical). Any glassware that contained solvents should be cleaned as follows:

1. Use the sink at bench 1 and rinse out the glassware with DI water from the sprayer or tap.
2. Add a small squirt of soap from the bottle located at that bench. Add some water to clean and rinse thoroughly with water.
3. Leave the rinsed out glassware on the drying rack located at that bench. Staff will return clean, dry glassware to the proper shelf.

10.10. Chemical Bottle Cleanup

Chemical bottle cleanup is the responsibility of the user who empties the container. Users are required to finish the clean up before leaving the lab, with no excuses.

Solvents

Solvent bottles must be completely dry before rinsing the bottle. To do this take the cap off the bottle and leave the open bottle under the fume hood at the solvent bench. The air flow and the low boiling point of the solvents will allow the remaining liquid to evaporate in about 2 hrs. If a user needs to leave earlier they can blow nitrogen into the bottle to speed up the evaporation. Once the bottle is completely dry, take the bottle over to the acid/base web benches. From there, fill the bottle completely with DI water, then dump the rinse water into the sink. Complete a fill and dump procedure a total of three times on each bottle. Once the bottle is cleaned, x-out the label of the bottle and write “Rinsed” 2 or 3 times around the bottle. Cleaned bottles can be left by the waste cabinets near the double doors leading to the office space.

Acids/Bases

Acid or base bottles do not need to be dry before rinsing out. Complete a fill and dump procedure a total of three times on each bottle. Once the bottle is cleaned, x-out the label of the bottle and write "Rinsed" 2 or 3 times around the bottle. Cleaned bottles can be left by the waste cabinets near the double doors leading to the office space.

10.11. Non-Emergency Spill Response Procedures

Emergency spills (considered to be anything over one gallon) must follow procedures outlined previously in section 5.8. For anything smaller than one gallon, WTC does not consider this an emergency situation and the following procedures can be applied for a given chemical.

Solvents

Solvents present a large flammability concern and not usually a significant health hazard in small volumes. Typically small spills will evaporate quickly, and can even be handled as such. The best way to clean up small volume solvent spills is with cleanroom wipes and soaking up the spill. Be sure to dispose of the wipes in the vented garbage container so solvent vapors do not remain in the lab. PPE should include gloves and goggles or safety glasses.

Acids/Bases (not Hydrofluoric Acid)

Acid or base spills on the floor need to be neutralized. Grab the appropriate neutralizer from the spill cart and some pH paper. Add neutralizer until a pH of near 7 is obtained. From there wipe up the spill with cleanroom wipes. If the spill occurs within a wet bench, it is easiest to dilute the spill with DI water from the sprayer at each wet bench. Squeegee the waste into the drain, or if it falls into the cracks of the wet bench this will also drain properly to the AWN system. Minimum PPE for cleaning up an acid/base spill is neoprene (black) gloves, eye protection (goggles or face shield), and an acid apron.

Hydrofluoric Acid (HF)

HF is a highly dangerous chemical to human health. For an HF spill users should start with full PPE: neoprene (black) gloves, acid apron, and eye protection (goggles or face shield). The spill cart has a HF spill kit that has chemicals that will convert HF into H_2SO_4 and MgF_2. From there the MgF_2 can be absorbed using supplies in the spill kit, and the H_2SO_4 can be neutralized before being absorbed. The absorber materials can be swept up using a dustpan in the spill kit. If the HF spill is very minor and within a bench then the dilution method described in the acid/base section above is appropriate. Please take HF spills very seriously.

10.12.Staff Maintained Baths

There are eight baths that are maintained by WTC staff for users. The location and frequency of change is noted below. Users are free to change the baths as needed. Staff will change any bath that is outdated or contaminated.

- EKC 830 – This solution is in the solvent bench nearest the spin rinse dryers. The solution is for positive photoresist strip only. It is changed weekly.
- AZ 300T – This solution is also in the solvent bench. The solution is for positive photoresist strip only. It is changed weekly.
- Standard Clean 1 (SC1) – This is a solution of 5:1:1 H_2O:H_2O_2:NH_4OH by volume. It is great for cleaning wafers of particulates by quickly building up and removing thin oxide films. This solution degrades quickly when heated for standard usage. It is located at wet bench #1. If it is more than three days old users should repour.
- Standard Clean 2 (SC2) – This is a solution of 5:1:1 H_2O:H_2O_2:HCl by volume. It is effective for removing metal contamination from wafers. The solution does not degrade nearly as quickly as SC1. It is located at wet bench #1. It is changed monthly.
- 49% Hydrofluoric Acid – Highest concentration form of HF at WTC. It is very effective at etching silicon oxide and glass at high rates. The solution is located at wet bench #3. It is changed monthly.
- 10:1 BOE Solution – BOE is short for buffered oxide etch and is a solution of NH_4F and HF at a 10:1 ratio by weight percent. The solution is approximately 60% of these two constituents and the balance water. This is a much more controllable oxide etchant than pure HF. Users must be aware that NH_4F is as dangerous as HF and needs to be treated in similar fashion. The solution is located at wet bench #3. It is changed monthly
- Potassium Hydroxide (KOH) – WTC creates a 1:1 solution of KOH:H_2O by volume. The starting KOH is 45% wt KOH balance water, so the final solution is around 23-25% wt. The bath is heated and most users employ temperatures between 70-80˚C. KOH is used for anisotropic etching of silicon and takes advantage of a near zero etch rate on {111} planes in silicon to create specific features. The solution is located in wet bench #4. It is changed bi-monthly or as-needed.

10.13.Dedicated Glassware

The WTC lab wishes to have dedicated glassware for some chemicals especially those with metal etchants. Most metals can act as electronic trap states in silicon and need to be avoided by users with electrical applications for their devices. Users are restricted to using dedicated glassware ONLY for the intended application. Dedicated glassware is located on the second

shelf of the glassware rack and will have printed labels on them to indicate the process. General purpose glassware will be located on the shelf below dedicated glassware.

10.14.Appropriate Labels

All glassware must have the proper labels on them to ensure safety. A label is expected to be present before it is poured until after it is disposed of. It is the user's responsibility to both make and remove labels for all glassware being used. Users can use a Sharpie marker to print their label directly on the glassware. A proper label requires:

- Chemical(s) with volumetric ratio if a solution is made
- Name of user
- Date poured
- If work requires it to be used overnight a phone number must accompany it.

Any glassware failing to meet these criteria can be immediately emptied and cleaned. Any materials will be relayed to lost and found. Users must remove their labels during cleanup or staff will conclude that the chemical was not disposed of properly. Sharpie markers can be removed with a wipe containing acetone or isopropanol.

10.15.Leaving Chemicals Overnight

Chemicals are only allowed to remain overnight for two processes: metal-lift off, or Silicon on insulator (SOI) device release. Metal lift-off using acetone can often be an overnight process. WTC will allow lift-off processes 24 hrs from the date poured before taking action. SOI wafers often need release at some point in the process and can take as long as four days. In this case WTC will allow release processes four days from the date poured before taking action. If either of these processes are left beyond their deadline, staff will attempt to call the user first. After that, glassware may be immediately emptied and cleaned, with any materials being put in lost and found.

11.0 RULE ENFORCEMENT

11.1. Reporting Problems

Communication is the key to making the lab run smoothly. Everyone is accountable for their actions to the lab support staff AND ESPECIALLY all other lab users. It is the duty of the users to understand all details and staff is here to clarify as needed. As staff cannot cover all areas of the lab at all times, self-policing by all users is needed. If any user witnesses another user violating any rules of this manual, being unsafe, or potentially harming another user's work, they must alert staff to such violations. Any WTC staff member can cite a user for rule violations and begin the discipline process. Staff is committed to providing a safe environment for all users to effectively achieve their goals. Reporting such problems will allow staff to correct mistakes and create an effective workspace. ATTITUDE IS KEY.

11.2. Violations

Staff will divide rule violations into three distinct categories: mild, moderate, and severe. It is up to the responding staff to determine which category they believe the violation falls into, and all violations are reviewed by all WTC lab staff at least weekly. The following description is meant to provide users with a framework of how WTC will decide the severity of a violation. Since many violations could occur in a number of situations, the ultimate decision may vary.

- Mild Violation – Small errors in judgment that have no immediate safety consequences for the user or others. Examples include poorly labeling glassware or violations to the equipment reservation policy. These violations would be typically met with a warning before a more serious penalty is adopted.
- Moderate Violation – Disregarding rules or policies that could potentially cause equipment damage or creates a potential safety concern. Examples include disregarding a standard operating procedure (SOP) for equipment or interfering with another user's work. These violations will typically be met with an immediate suspension from the lab for one or two days.
- Severe Violation – Blatant disregard for rules or policies that creates a safety concern or damages equipment. Examples of this would be mixing dangerous chemicals, or improper use of personal protective equipment (PPE). Bringing dangerous chemicals into the lab without prior staff authorization.

11.3. Discipline

Discipline will be carried out according to the severity of the violation as determined by staff. Just as there are always extenuating circumstances with the violation, the disciplinary action may not follow a specific standard. WTC seeks to create a general framework associating

points with violations. Users with a low amount of points may receive short suspensions; while a high enough point level will cause permanent expulsion from the lab. Mild violations will add 1 point to the user's record, while moderate violations will add 3 points to the user's record, and severe violations will add 5 points to the user's record. The point values may be raised or lowered by other circumstances in the violation. A monthly summary of disciplinary actions will be posted in the gowning room to make users aware of any violations.

Disciplinary Action

The points will lead to the following actions:

1. Warning – User will be asked to immediately correct the mistake
2-5. 1-4 day Suspension – User will be asked to leave the lab immediately for the remainder of the day plus additional days upon the level of the offense (4 points is remainder of day plus 2 days of additional suspension)
6-7. 1-2 week Suspension – User will be asked to leave for 1 or 2 entire working weeks.
8-9. 1-2 month Suspension – User will be asked to leave for 1 or 2 months.
10. Permanent Expulsion – User will not be allowed in the lab again.

If any user reaches 5 points, their company or principal investigator will be contacted by the lab manager for a meeting between the user, supervisor, and WTC lab staff. The goal will be corrective action to avoid any further problems.

Probationary Period

Points will eventually be removed from a user's record assuming no further problems are reported. The following will be a guideline for how long points stay on an individual's record. The final decision will be made at the same time the points are decided for the violation.

- Mild Violation – Points on record for 3 months (90 days)
- Moderate Violation – Points on record for 6 months (180 days)
- Severe Violation – Points on record for 1 year

12.0 REVISION HISTORY

Date	Individual	Reason for Change
3/5/2008	M.E. Hjelmstad	Version 1.0. Released to users, put into effect March 20, 2008
9/20/2010	Hjelmstad	Change Staff List, added chapter on CORAL and removed chapter on lab website. Updated Appendices to include CORAL interlocks. Touched up some protocol/rules.
11/8/2010	Hjelmstad	Edit to the Overnight policy, and CORAL alterations.

Appendices

A. Recommended Reading

For general knowledge related to all facets of silicon processing:

- S. Wolf and R.N. Tauber, *Silicon Processing for the VLSI Era, Vol. 1: Process Technology* (Lattice Press, Sunset Beach, CA, 2000).
- O.D. Trapp, L.J. Lopp, and R.A. Blanchard, *Semiconductor Technology Handbook, 6th Ed.* (Technology Associates, Portola Valley, CA, 1993).

For general knowledge related MEMS design and function and some processing:

- M. Gad-el-Hak (editor), *The MEMS Handbook* (CRC Press, New York, 2002).
- M.J. Madou, *Fundamentals of Microfabrication, 2nd Edition* (CRC Press, New York, 2002).
- G.T.A. Kovacs, *Micromachined Transducers Sourcebook* (WCB McGraw-Hill, Boston, 1998).

Process Specific Books or Review Articles:

- Q.Y. Tong and U. Gösele, *Semiconductor Wafer Bonding* (John Wiley & Sons, New York, 1999).
- B. Wu, A. Kumar, and S. Pamarthy, "High Aspect Ratio Silicon Etch: A Review", *J. Appl. Phys.*, **108**, 051101 (2010).

Detailed reference on etching methods and rates in microfabrication (copy is always in the lab):

- K.R. Williams and R.S. Muller, "Etch Rates for Micromachining Processing", *J. Microelectromech. Sys.,* **5**, 256 (1996).
- K.R. Williams, K. Gupta, and M. Wasilik, "Etch Rates for Micromachining Processing – Part II", *J. Microelectromech. Sys.*, **12**, 761 (2003).

B. Cleanroom Operation

A cleanroom is described as a work area in which the air quality, temperature and humidity are highly regulated in order to protect sensitive equipment from contamination. The cleanroom at the Microfabrication Laboratory is certified class 10,000 (or ISO 7). A cleanroom class signifies the maximum number of 0.5μm or larger particulates that occupy a cubic foot. The measurements are taken with particle counters and follow US FED standard 209E. A class 10,000 cleanroom is considered to be cleaner than the standards of a hospital operating room.

To maintain the cleanroom specification WTC has high-efficiency particulate attenuation (HEPA) filters in the ceiling throughout the cleanroom. The lab air is a mix of fresh air from the supply fans and recirculated air from the PACE or Pomona recirculators in the lab. The lab air is forced through the HEPA filters into the cleanroom. From there the lab air escapes the cleanroom through doors or under walls (in high-temperature room). The cleanroom maintains a positive pressure compared to surrounding areas in order to force air out of the lab and continually replace the lab air with filtered air from the HEPA filters. A fraction of the lab air is recirculated via fan units. These fan units have HEPA pre-filters in the intake path. Lab air is pulled in through the pre-filters and through the fan units which direct air back to the ceiling HEPA filters and back into the cleanroom. In the photolithography, metrology, and thin film rooms, these recirculating fans are the PACE units mounted against the wall inside the cleanroom. In the high-temperature and back-end processing rooms, the recirculating fans are the Pomona units standing immediately outside the lab area.

C. Equipment with CORAL interlocks

Within CORAL interlocks are signaled from a source computer which is in turn connected to the main CORAL server. This list summarizes all the equipment interlocked by CORAL and the location within the CORAL infrastructure. Each source computer has a control card capable of accessing 25 different interlocks.

CORAL name	Description	Category	Source	Interlock #
CEE1	CEE Spinner #1	Photolith—Coat	Coraleqc1	10
CEE2	CEE Spinner #2	Photolith—Coat	Coraleqc1	11
Headway	Headway Spinner	Photolith—Coat	Coraleqc1	12
EVG-Aligner	EVG Contact Aligner	Photolith—Expose	Coraleqc1	1
ABM-Aligner	AB-M Contact Aligner	Photolith—Expose	Coraleqc1	15
3in-Quintel	Quintel Aligner – 3” System	Photolith—Expose	Coraleqc1	14
Flood-Expose	UV Flood Exposure System	Photolith—Expose	Coraleqc2	16
Spin-Dev	Laurell Spin Developer	Photolith—Develop	Coraleqc1	7
HMDS	HMDS Oven	Photolith--		
EBeam-Lithography	JEOL 6300 E-beam Lithography Direct Write	Nanolith	Coraleqc1	17
DipPen	Dip-Pen Nanolithography System	Nanolith	Coraleqc1	4
Nanoimprint	Nanoimprinter	Nanolith	Coraleqc1	16
PECVD	PECVD	CVD/Furnaces—CVD	Coraleqc2	4
LPCVD-Nitride	LPCVD – Silicon Nitride	CVD/Furnaces—CVD	Coraleqc2	2
LPCVD-LTO	LPCVD – Low Temp Oxide	CVD/Furnaces—CVD	Coraleqc2	3
AtmTube1	Furnace – Tube 1	CVD/Furnaces—Furnace Tubes	Coraleqc2	6
AtmTube2	Furnace – Tube 2	CVD/Furnaces—Furnace Tubes	Coraleqc2	7

AtmTube3	Furnace – Tube 3	CVD/Furnaces—Furnace Tubes	Coraleqc2	8
AtmTube4	Furnace – Tube 4	CVD/Furnaces—Furnace Tubes	Coraleqc2	9
CNT-Reactor	Carbon Nanotube Reactor	CVD/Furnaces—Furnace Tubes	Coraleqc2	1
RTA-Clean	Rapid Thermal Annealer – Silicon/Clean	CVD/Furnaces—Rapid Thermal Annealing	Coraleqc2	10
RTA-Other	Rapid Thermal Annealer – Metal/Other	CVD/Furnaces—Rapid Thermal Annealing	Coraleqc2	11
Ebeam-Clean	E-beam Evaporator – Clean	Metallization—Evaporation	Coraleqc3	10
Ebeam-Liftoff	E-beam Evaporator – Lift-off	Metallization—Evaporation	Coraleqc3	11
Sputter-Lesker	KJ Lesker Lab 18 Sputter	Metallization—Sputtering	Coraleqc3	1
Sputter-Oxford	Oxford Magnetron Sputter	Metallization—Sputtering	Coraleqc3	7
GoldBath	Gold Electroplating Bath	Metallization—Electroplating	Coraleqc1	8
DRIE	Deep Reactive Ion Etcher	Dry Etching	Coraleqc3	2
Tegal	Tegal Oxide Etcher	Dry Etching	Coraleqc3	4
Trion	Trion Reactive Ion Etcher	Dry Etching	Coraleqc3	5
BarrelEtch	Branson Barrel Etcher	Dry Etching	Coraleqc1	5
ICP-Fluorine	Oxford ICP Etcher – Fluorine	Dry Etching	Coraleqc2	5
ICP-Chlorine	Oxford ICP Etcher – Chlorine	Dry Etching	Coraleqc3	8
Vision-RIE	Vision Mark 320 RIE	Dry Etching	Coraleqc3	5
P15	P-15 Profilometer	Metrology—Profilometry	Coraleqc1	23
Wyko	Wyko Non-contact Profiler	Metrology—Profilometry	Coraleqc1	20
Leica	Leica Optical Microscope	Metrology—Microscopes	Coraleqc1	21
JEOL-SEM	JEOL Scanning Electron Microscope	Metrology	Coraleqc1	18
EVG-Bonder	EVG Wafer Bonder	Misc—Wafer Bonding	Coraleqc1	2
KS-Saw	K&S Dicing Saw	Misc—Back-End	Coraleqc2	14
Tempress-Saw	Tempress Dicing Saw	Misc—Back-End	Coraleqc2	19
CO2-Laser	CO2 Laser	Misc—Back-End	Coraleqc2	15
WireBond	Wire Bonder	Misc—Back-End	Coraleqc2	18
ScreenPrinter	Screen Printer	Misc—Printing	Coraleqc2	17

D. Facilities

WTC operates four significant facilities that support the Microfabrication Laboratory: the deionized (DI) water plant, the acid waste neutralization (AWN) system, a fume scrubber and burn box for lab exhaust, and a HAZMAT emergency system. The first three support a variety of aspects of the lab and without them would shutdown the laboratory until the facility was restored. The hazardous material (HAZMAT) system supports the chemical vapor deposition (CVD) systems which use three pyrophoric gases: silane, dichlorosilane (DCS), and anhydrous ammonia. Alarms with the HAZMAT system can be minor and disable the CVD system or could be full alarms requiring a building evacuation. The remaining facilities are critical to the lab and are maintained by other personnel. These include: solvent and acid exhaust, liquid nitrogen, compressed air, house vacuum, supply air, fans, PACE and Pomona recirculators, gas bunkers, and the house nitrogen system.

Fume Scrubber

The fume scrubber is located on the lab area rooftop at the south side of Fluke Hall. The burn box is located in the middle bunker on the south side of Fluke Hall. The burn box, which is also called an exhaust gas conditioner, is a heater element that is maintained somewhere between 800 and 850˚C. Any exhaust from the CVD systems that may contain one of the hazardous gases (silane, DCS, or ammonia) is routed to the burn box. The gases are pyrolyzed in the burn box to avoid any potential of fire or explosion. The pyrolyzed gases are run through a small scrubber before being routed to the rooftop scrubber.

The rooftop scrubber contains 5 water manifolds with several jets that shower water through a volume within the scrubber. This volume is filled with plastic packing media which force the exhaust gases to make multiple changes in direction. This makes the mean free path through the exhaust very short and the transit time through the media very long. The result is a greater opportunity to scrub the exhaust gas. The water reacts with the acidic or basic vapors to hydrolyze the dangerous elements. The water that goes through the scrubber is periodically drained into the AWN system. All vapors from acid/base fume hoods, certain mechanical pumps, and the burn box are routed to the rooftop scrubber. Solvent vapors under solvent hoods are routed to a different exhaust.

Burn Box

The burn box is also called an exhaust gas conditioner as it is used to burn off volatile lab exhaust gases at approximately 800-850˚C before routing it to the rooftop fume scrubber. The burn box has its own small scrubber which gases travel through just after being pyrolized. The burn box is only applicable to the CVD systems in the lab where

silane, dichlorosilane, and ammonia are used. The CVD systems are all low-pressure systems so all exhaust is pulled into the vacuum pump. The vacuum pump is what is exhausted into the burn box to ensure that a toxic gas is volatilized before entering the fume scrubber. Without the burn box being operational, a significant explosion hazard would exist in the fume scrubber.

Deionized Water (DI) Plant

The DI water plant is located in the mechanical room of Fluke Hall. It feeds the lab a recirculating loop of DI water that is plumbed through thick plastic tubing which may be visible throughout certain parts of the building. The plant is fed city water which is pumped through reverse osmosis membranes which help remove impurities (mainly metal ions) from the water stream. A certain percentage of the water entering the membranes pass through the membranes to make product, some water is originally rejected but recirculated through again, and a certain percentage is rejected entirely to the city wastewater system. The product DI water is contained in a 400 gallon holding tank. Level sensors on this tank determine when the plant is working to create more DI water or when it is only circulating the loop. The water is circulated from this tank by two large pumps. The water goes through a final filtration, ultraviolet (UV) bacteria kill, and resistivity monitor before entering the lab loop. The DI water is specified to have a resistivity of 18.1 MΩ-cm when tested at the monitor. Water that goes through the loop unused returns to the 400 gallon holding tank to be reused.

Acid Waste Neutralization (AWN) System

The AWN system is located in the chemical storage area adjacent to the loading dock of Fluke Hall. All lab wastewater drains to a holding tank within the system, no lab waste can go directly into the city waste unless going through the floor drains. All aspirators drain with added DI water to the same holding tank. It is critical that users use the aspirators whenever possible to ensure that strong acids or bases are diluted properly and do not cause a serious danger within the waste lines. The holding tank is regularly discharged into the main neutralization tank. This tank is under constant mixing and the pH is consistently monitored. If the tank is too basic, concentrated sulfuric acid is slowly added to the neutralization tank. Likewise, if the tank is too acidic, liquid caustic soda is slowly added. If the tank reaches the appropriate level sensor, AND the pH is between 5.5 and 11, then tank will discharge approximately 340 gallons into the city wastewater system. WTC is responsible through the wastewater permit to ensure that the discharged wastewater is within the proper pH, that a limited amount of waste is discharged, that the level of trace metals (gold, copper, mercury, etc.) is sufficiently low, and that absolutely no toxic organics (TTOs) are discharged. The system ensures the

first two points, and a monthly independent test of the wastewater ensures the last two. King County conducts two tests per year that check these factors over a 24-hour period.

Gas Detection

The HAZMAT alarm system is housed in the emergency response room located on the east side of the building between the entrances to the lab office area and the Nanotech Center hallway. The system contains detectors for each of the toxic gases used in the CVD systems. There are several air sampling points throughout the building. The air is pumped back to the HAZMAT system and sprayed across chemically-reactive tapes. Hydrides tape detects silane, aliphatic amines tape detects ammonia, and mineral acids tape detects dichlorosilane. Any reaction with the tape creates a change in color that is detected by an optical sensor and would trigger a HAZMAT alarm. The system is also tied into the building fire alarm.

Emergency Response Room

The bunker housing the HAZMAT system is the rallying point for all emergency response individuals. The gas detection systems described above are housed in this location. Self-contained breathing apparatuses (SCBA) are kept in this location if staff needs to be involved in any HAZMAT response. Lab will also keep several other important HAZMAT items in the bunker such as mobile gas detectors, two-way radios, flashlights, and HAZMAT suits.

Solvent and Acid Exhaust

Fluke Hall is plumbed with exhaust for the wet benches. Two distinct exhaust systems exist for the different fumes and environmental protection requirements. Solvent fumes are routed through the building rooftop with no scrubbing capability. The acid/base exhaust from the lab is plumbed directly to the fume scrubber. Other building acid/base exhaust is directed through a different exhaust path and released without scrubbing.

Liquid Nitrogen

WTC has a liquid nitrogen (LN_2) storage tank located on the south side of the building near the loading dock. The tank is maintained by BOC Edwards in Hillsboro, OR, and is typically filled twice a week. The storage tank supplies all liquid nitrogen, and compressed nitrogen gas for the lab. A fill station exists in the lab that allows staff to fill dewars for different applications in the lab. The system outside has a heat exchanger system that allows the liquid to be heated and evaporated into gaseous nitrogen. During the heating, the gas is compressed to approximately 95 psi.

House Compressed Air System

WTC has a compressed air system housed in the mechanical room that supplies the lab. WTC has used the system for pneumatics in systems such as the furnace stacks or sputtering systems. Compressed air lines are marked as such or often CDA for compressed dry air. The gas is compressed to approximately 100 psi.

House Vacuum

A house vacuum exists for systems requiring low vacuums. WTC uses the house vacuum in applications where wafers must be held in locations such as on spinners or vacuum wands for wafer handling. The vacuum pumps for the system are housed in the chemical storage area just off the loading dock. The pumps activate when the system vacuum is -18 inHg, and deactivate once they have brought the vacuum to -25 inHg.

Supply Air, Fans, Pace & Pomona Units

Fans, Pace, and Pomona units create all the lab air for the cleanroom. Supply fans are located on the roof of Fluke Hall and supply the lab with fresh air. Pace and Pomona units are recirculators that allow the significantly high refresh rate of air in the lab. The incoming air to the lab is a mix of fresh air and recirculated or “make-up” air from the Pace or Pomona units. The incoming air is what is forced through the HEPA filters and into the lab. The Pace and Pomona units both have pre-filters that filter air leaving the cleanroom before it is recirculated back into the lab.

Gas Bunker

The gas bunker is a concrete structure on the south side of Fluke Hall and has four separate rooms. The first is reserved for a special cleaning system for the lab. Another room is reserved for the burn box system. A third room houses the storage cabinet for the ammonia cylinder for the CVD system in the lab. The final room houses several gas cylinder storage cabinets. Within this room are the silane, dichlorosilane, boron trichloride, chlorine, and silicon tetrachloride cylinders for processing. This room specifically is fitted with a blast door and is designed to use explosion proof facilities. In the event of an explosion the door would blast out, away from the building. The silane, ammonia, and burn box rooms are all outfitted with hazardous gas monitors that are relayed back to the emergency response room. All rooms in the gas bunker are exhausted with a very strong flow rate to the fume scrubber system.

E. Consumables at WTC (standard vs. extra-cost items)

Supplied by WTC to all users as part of their usage fees:

Chemical/Material	Category	Supplier
Acetone	Solvent	VWR (JT Baker)
2-Propanol	Solvent	VWR (JT Baker)
P-20 Primer	Solvent	Shin-Etsu
HMDS Primer	Solvent	Shin-Etsu
SU-8 Developer	Solvent	MicroChem
EKC 830	Solvent	EKC Technology
AZ 300T Resist Stripper	Solvent	Mays Chemical
Pad Etch 4	Acid	Alameda Chemicals
Aluminum Etch (16:1:1:2)	Acid	VWR (JT Baker)
Hydrofluoric Acid	Acid	VWR (JT Baker)
Hydrochloric Acid	Acid	VWR (JT Baker)
Sulfuric Acid	Acid	VWR (JT Baker)
10:1 Buff. Oxide Etch	Acid	VWR (JT Baker)
Nitric Acid	Acid	VWR (JT Baker)
Acetic Acid	Acid	VWR (JT Baker)
TFD Chromium Etch	Acid	Transene
TFA Gold Etch	Acid	Transene
TFS Silver Etch	Acid	Transene
Nickel Etch	Acid	Transene
APS Copper Etch	Acid	Transene
Hydrogen Peroxide	Oxidizer	VWR (JT Baker)
Ammonium Hydroxide	Base	Alameda
Potassium Hydroxide	Base	VWR (JT Baker)
AZ 400K Developer	Base	Mays Chemical
AZ 340 Developer	Base	Mays Chemical
MF 319 Developer	Base	Microchem
Futurrex RD6 Developer	Base	Futurrex
AZ 1512 Photoresist	Pos. Resist (Solvent)	Mays Chemical
AZ P4620 Photoresist	Pos. Resist (Solvent)	Mays Chemical
Futurrex NR71-1000PY	Neg. Resist for Liftoff	Futurrex

The following list is chemicals or supplies that are available to users from WTC at an additional charge. These items are kept for the convenience of users who cannot buy large quantities of these items. The WTC charges an additional percentage over cost to cover storage costs. WTC staff is also happy to direct users to the proper vendor if they would like to purchase from them directly.

Chemical/Material	Category	Supplier
Single Wafer Carrier – Top or Bottom	Materials	Entegris

Single Wafer Carrier – Spring	Materials	Entegris
Cleanroom Notebook	Materials	VWR
Metal Dicing Blade (for Tempress)	Parts	Kulicke & Soffa (Semitec)
Resin Dicing Blade (for Tempress)	Parts	Thermocarbon
Resin Dicing Blade (for K&S)	Parts	Thermocarbon
Xacto Knife	Materials	VWR
Carbon Crucible (Au e-beam)	Parts	Kurt J. Lesker
Carbon Crucible (Al e-beam)	Parts	Kurt J. Lesker
Timers	Materials	VWR
Timer Batteries	Materials	VWR
Tweezers	Materials	VWR
Wafer Tongs	Materials	VWR
Diamond Scribe	Materials	VWR
Crystal Bond Wax	Chemicals	VWR
Silicon Wafers, 100mm, Prime Grade	Substrates	Montco Silicon
Silicon Wafers, 100mm, Test Grade	Substrates	Montco Silicon
Silicon Wafers, 100mm, DSP	Substrates	Montco Silicon
Silicon Wafers, 3”, Prime Grade	Substrates	Montco Silicon
Borofloat Glass Wafers, 100mm, DSP	Substrates	Mark Optics
Gold Evap Source, 99.999% pure	Metals	Kurt J. Lesker
Platinum Evap Source, 99.99% pure	Metals	Kurt J. Lesker

F. Locker Policy

Lockers are issued on a yearly basis from July 1 to June 30. All lockers should go through a thorough cleanout before the beginning of the next year. Users must request a renewal each year if they plan to use the locker. Renewals will be given priority over new requests, provided the user is meeting their hourly billing cap on their user agreement. Failure to comply with this document can result in the revocation of locker privileges

- Locker policy may change at any time. Users with lockers will be notified of the changes and given a one-week grace period to make any alterations to comply with a revised policy.
- Lockers are intended for common lab items except chemicals. Acceptable items include: safety glasses, lab notebooks or journal articles, small tools such as wafer tongs, tweezers, and diamond scribes. Metal sources for the evaporator are acceptable with well labeled containers. Wafers are acceptable but not recommended to be stored in lockers.
- Absolutely no chemicals are allowed in the lockers. Chemicals in lockers will result in immediately loss of locker privilege.
- Cleanroom garments are not to be kept in lockers.
    - Special Exemption – Smocks and hoods are allowed to be kept in a user's locker if they have just put their latest garments in the laundry on Monday afternoon/evening, and will be using the stored garments on Tuesday morning before the regular laundry delivery (8 a.m., Tuesdays). The garments must stay in the vacuum sealed bags if they are stored in the lockers under this exemption.
- No locks on lockers. WTC staff is allowed to check the contents of any locker at any time to ensure that excluded items are not kept in lockers.
- Lockers are issued to a company or academic principal investigator (PI), with a maximum of two lockers to any single company or PI. The lab manager must be informed of all individuals with access to use the lockers. Any changes must be communicated to the lab manager.
- Lockers are assigned at the discretion of the lab manager. Priority is given to users that reach the billable hours cap according to their user agreements.
- Restricted cleanroom items (food, drink, pencils, cardboard) are not allowed in lockers.
- Lockers do not guarantee privacy. Users are not recommended to store valuable or personal items in lockers. WTC is not responsible for any stolen or lost property.
- Lockers should remain clean. If an excessive amount of material is stored in a locker this could result in loss of privilege. This is the discretion of the lab staff.

G. Lab Visitor Form

WASHINGTON TECHNOLOGY CENTER

MICROFABRICATION LABORATORY

LAB VISITOR FORM

As a guest at Washington Technology Center's (WTC) Microfabrication Laboratory,

I, _____ represent _____
(Print name) (Company/Organization)

_____

(Company/Organization address or residence if representing self)

1. I realize that hazardous chemicals and hazardous wastes are generated at this site. I may request that the work areas where there is a possibility of contact with these materials be identified to me and Material Safety Data Sheets made available upon request. I may contact the Laboratory Manager at (206) 616-3855 for further information.

2. I agree to conduct myself in a manner suitable for the shared space environment of the Microfabrication Laboratory.

3. I agree to wear all safety equipment appropriate for the laboratory and any processes I may witness. Aprons, face shields, gloves, and safety glasses are available upon request.

4. I realize that observing a laboratory user does not constitute equipment training or certification. The laboratory staff performs all equipment training and certification.

5. I am aware that there are emergency evacuation procedures for this site. Fire exits, fire routes, fire alarm pull boxes, and safety showers are identified. A laboratory map is available upon request. I may contact any laboratory staff member for further information.

6. I acknowledge and agree to comply with WTC safety provisions, including, but not necessarily limited to those provided on this form.

Signed:_____Title:_____Date:_____

Approved By:_____
(WTC laboratory staff)

H. CORAL ALTERATION REQUEST

WASHINGTON TECHNOLOGY CENTER

MICROFABRICATION LABORATORY

CORAL ALTERATION REQUEST

Please fill out the form appropriately, and e-mail a copy to the lab manager at MFL_LabManager@watechcenter.org

The Lab Manager will review the request and respond to this form within 24 hours. WTC asks that the user retains a copy of this form for record keeping. Please use this form for only one specific request, multiple alterations require multiple requests.

Name: _____ CORAL username: _____

Company/Academic Group: _____

Equipment: _____ Date/Time: _____

Description:

Alteration Approved? Yes No

Finding:

Determined by: _____ Date: _____