User Name & ID (Print):

PI (subject to change):

User Signature & Date:

Research Focus (subject to change):

User e-mail:

Extreme Hazards	Process Name	User Initials	Qualifier Initials	Date	User Initials	Qualifier Initials	Date	User Initials	Qualifier Initials	Date
	Acetic Acid, Glacial									
	Ammonium Fluoride									
	Ammonium Hydroxide									
	Aqua Regia									
	Buffered Oxide Etch									
	HNA									
	Hydrochloric Acid (HCl)									
	Hydrofluoric Acid (HF)									
	Hydrogen Peroxide									
	Nitric Acid									
	PAN									
	Phosphoric Acid									
	Piranha									
	Potassium Hydroxide									
	RCA1 (Base)									
	RCA2 (Acid)									
	SulphoNitric									
	Sulphuric Acid									

Chemical Handling and Equipment	Process Name	User Initials	Qualifier Initials	Date	User Initials	Qualifier Initials	Date	User Initials	Qualifier Initials	Date
	Breadth of Hazards									
	Haz Waste Management									
	Labeling Experiments									
	Pouring and Mixing									
	PPE Choice & Cleaning									
	Sharps									
	Work Station Use									
	KOH Bath									
	RCA Bath									
	Sonicators									
	Stir- and Hotplates									

Users: By initialing, you agree that you understand and will follow the SOP.
If you forget any rules it is your responsibility to seek help from the lab staff, who will happily provide further training.

User Name & ID (Print): ____________________

Tools	Process Name	User Initials	Qualifier Initials	Date	User Initials	Qualifier Initials	Date	User Initials	Qualifier Initials	Date
	Alcatel DRIE									
	Cannon Aligner									
	CHA E-beam Evaporator									
	CHA Sputterer									
	CPD									
	Dektak 3030 and/or 2A									
	Dicing Saw									
	EVG Aligner									
	FEI NanoSEM									
	FirstNano Nanowire CVD									
	Karl Suss MA-4									
	Lesker Sputter									
	Mann PG									
	MRL Furnace									
	Nanonex									
	PlasmaTherm Etcher									
	RTP									
	Solitec Spinner/Hotplate									
	Spin Rinsers									
	Technics PECVD									
	Technics RIE									
	UV Flood									

Common Lesser Hazards	Process Name	User Initials	Qualifier Initials	Date	User Initials	Qualifier Initials	Date	User Initials	Qualifier Initials	Date
	Aqueous Developers									
	Chrome Etch									
	DMSO									
	EBL Developer									
	Halogenated Solvents									
	Monolayer Deposition									
	PR Diluents & Strippers									
	Squirt Bottle Solvents									
	Standard Photoresists									

Users: By initialing, you agree that you understand and will follow the SOP.

If you forget any rules it is your responsibility to seek help from the lab staff, who will happily provide further training.

If you intend to use any of the listed chemicals, you must answer all of the following Common Procedures

------------------------Common Procedures--------------------------

Breadth of Hazards

1. What PPE should you wear if approaching an unknown chemical? Make sure to include everything you would use to protect your body, hands and face beyond your standard cleanroom wear.
2. What are the 3 major possibilities for explosions at NCNC?
3. What makes anesthetic chemicals so dangerous?

Haz Waste Management

1. You can conveniently aspirate almost any **acid** solutions at NCNC. What is an exception? There are many possible answers, but please pick just one.
2. What should you do with nearly empty bottles of chemicals? Should you return the bottle to its cabinet or discard the remaining chemicals and rinse the bottle?
3. If a waste bottle creates toxic fumes, how tightly should you cap it if using a normal cap?

Labeling Experiments

1. In what cases can you use chemical acronyms when labeling an experiment?
2. What should you put on overnight chemical bath labels?
3. Can you write your label on a tekwipe?

Pouring and Mixing

1. When mixing concentrated acids/bases with water, which should you mix into which?
2. When pouring hazardous materials from a bottle while wearing full PPE, why should you keep the base of the bottle over the work bench?
3. Roughly how long must you stir Sulphuric acid and water for the materials to fully mix and finish releasing heat?

PPE Choice and Cleaning

1. For each of the following, should you use a black or a blue glove: Acids, Bases, Oxidizers, Organics?
2. What processes are you allowed to double glove (wear a second pair of white nitriles) for?
3. How can you keep a pair of black butyl/Viton gloves clean when working messily with resist?

Sharps

1. Name any two common sharps at NCNC.
2. Where can you find gauze and bandages for first aid? Name any of the several locations.
3. Name any two of the common signs of infection.

Work Station Use

1. Which NCNC provided chemicals (if any) can attack a wetbench workstation (plenum) top?
2. How can you determine the pH of residues on a wetbench workstation (plenum).
3. What cleanroom device can you use to quickly remove rinse water from cleaning a wetbench workstation (plenum) top?

----------------------Chemicals and Mixtures-------------------

Acetic Acid

1. How resistant are NCNC's blue heavy nitrile gloves to concentrated (>40%) Acetic acid? Are they not resistant, splash resistant or emersion resistant?
2. Can you ignite heated Acetic Acid?
3. Should you store a new bottle of Acetic Acid with acids, organics or elsewhere?

Ammonium Fluoride
1. You find a spill that might be Ammonium Fluoride. What would the pH be?
2. What is the easiest way to dispose of Ammonium Fluoride solution that do not contain heavy metals?
3. Will heated Ammonium Fluoride create a vapor hazard? How about room temp?

Ammonium Hydroxide
1. How long will Ammonium Hydroxide residues last in cleanroom conditions? hours, weeks, years?
2. (Part 1) Will heated Ammonium Hydroxide present a vapor hazard? (Part 2) How about room temp?
3. What side effect will occur if your nose tingles from inhaled Ammonia fumes.

Aqua Regia
1. Is Aqua Regia a transient or persistent oxidizer?
2. Why should you mix a new batches of Aqua Regia rather than storing and re-using old ones?
3. Can you use Aqua Regia with Teflon beakers or dishes at NCNC?

BOE
1. You find a spill that might be BOE. What would the pH be?
2. How long do BOE burns take to become apparent? minutes, hours, days?
3. What is the easiest way to dispose of BOE solutions that do not contain heavy metals?

HNA
1. When capping an HNA waste bottle, how do you avoid explosion?
2. What labware can you use with HNA? Polypropylene, Teflon, Pyrex, Aluminum, Stainless?
3. What danger will you face when etching Silicon, especially in hot HNA?

Hydrochloric Acid (HCl)
1. Can you ignite hot HCl?
2. What additional contact hazard should you be cautious of if etching metals in HCl?
3. What is the white mist that erupts from HCl bottles?

Hydrofluoric Acid (HF)
1. Can you smell HF vapors before they reach chronically hazardous levels?
2. Is the poor splash warning-property more likely for diluted (~20%) or concentrated (~49%) HF?
3. Where at NCNC can you use hot baths of HF? Name all the possible locations.

Hydrogen Peroxide
1. Why do Hydrogen Peroxide bottles have special caps? What do they prevent?
2. Why should you never mix solvents (liquid organics) into H_2O_2?
3. When using a waste bottle of Hydrogen Peroxide with a non-venting cap how many “turns from tight” should the cap be?

Nitric Acid
1. What class (or classes) of chemical is Nitric Acid? Acid, Base, Fluoride, Organic, Oxidizer?
2. What and how hazardous is the brown gas that Nitric Acid occasionally emits?
3. Why is it hazardous to mix liquid organics into nitric acid?

PAN
1. When using a waste bottle of PAN with a non-venting cap how many “turns from tight” should the cap be?
2. Where can you dispose of PAN used to etch large amounts of Aluminum?
3. What is the NCNC approved mixing order of PAN? Don’t forget the water!

Phosphoric Acid

1. How long will residues of Phosphoric acid persist? Hours, Weeks, Years?
2. Does Phosphoric acid have a vapor hazard at room temperature?
3. How does boiling Phosphoric acid create an especially hazardous vapor and residue?

Piranha

1. Though permitted, what hazards occur when mixing Hydrogen Peroxide into Sulphuric Acid rather than the NCNC recommended vice-versa?
2. Is Piranha a persistent or transient oxidizer?
3. Glycerol (a solvent) is added to many etches to attenuate the etch. Why would it be bad in Piranha?

Potassium Hydroxide

1. What and how hazardous are the bubbles formed when using Potassium Hydroxide as an etchant?
2. Where can you use hot baths of Potassium Hydroxide? Name all the possible locations.
3. Will concentrated (~50%) Potassium Hydroxide fume or leave hazardous residues at room temperature?

RCA1

1. What class (or classes) of chemical are in RCA1? Acid, Base, Fluoride, Organic, Oxidizer?
2. Where in NCNC can you use heated RCA1? Name all the possible locations.
3. What fumes will erupt from a heated RCA1 bath?

RCA2

1. When using a dedicated RCA bath can you add hydrogen peroxide after heating the rest of RCA2?
2. After using RCA2 on mostly clean wafers, can you decant (dump) RCA2 to the neutralizer?
3. What color is RCA2?

SulphoNitric

1. Are the residues created when simmering/boiling SulphoNitric temporary or long-lasting?
2. What is the first sign of a runaway etching in hot SulphoNitric? How should you stop it?
3. What may happen if you mistakenly dispose of SulphoNitric in the waste bottle for Piranha?

Sulphuric Acid

1. How resistant are NCNC's blue heavy nitrile gloves to concentrated (>40%) Sulphuric acid? Are they not resistant, splash resistant or emersion resistant?
2. How long will residues of Sulphuric acid persist? Hours, Weeks, Years?
3. When you first pour Sulphuric acid into water, it doesn't mix or heat up. How long should you stir to mix the two and create heat?

Breadth of Hazards

Process:
At NCNC, you will be working around a wide variety of concentrated hazardous chemicals. To keep safe, you must understand the potential hazards of all NCNC chemicals. You will not need to know how to effectively work with every chemical you may be exposed to, but you must be aware of their presence and their hazardous properties in order to work around them safely.

Materials:
Liquid chemicals can be broadly summarized as acids, bases, fluorides, organics (aka. solvents/fuels) and oxidizers. You can anticipate which class (or classes) a chemical will be by its name:
Acids' names end in "Acid" .
Bases' names end in "Hydroxide".
Fluorides' names contain "Fluori-"; Names containing "Fluoro-" are not considered fluorides for this.
Organics' names end in "ane" "ene" "one" "ol" or "yde".
Oxidizers' names contain "Peroxide" or "Nitr-".

Common examples at NCNC include: Acetic Acid, Ammonium Fluoride, Ammonium Hydroxide, Hydrochloric Acid (HCl), Hydrofluoric Acid (HF), Hydrogen Peroxide, Nitric Acid, Potassium Hydroxide, Phosphoric Acid, and Sulphuric Acid. When combined, the above materials can form the following common mixtures: Aqua Regia, BOE, HNA, PAN, Piranha, RCA1, RCA2, and SulphoNitric.

Almost every chemical and mixture looks identical to water, so you will need to treat unknown chemicals with enough care that you won't get hurt regardless of the possibilities.[1]

Incompatible Materials:
Avoid mixing unknowns and avoid mixing chemicals from different classes because some mixtures will create excessive heat, toxic gasses, or explosives. As written in the 'mixing' SOP[3]: Mixing compatible chemicals correctly creates little additional hazard. Mixing acids and bases creates excessive heat and can splatter chemicals from floor to ceiling. Mixing oxidizers and organics can form explosive solids or highly flammable liquids. Mixing oxidizers with acids or bases often powerfully amplifies the oxidizer's reactivity and creates toxic gasses and explosives. Mixing organics with acids or bases occasionally makes 'condensate' gunk. Although there are hazards to mixing chemicals of different classes, these sorts of mixtures are still commonly made at NCNC. Almost all of the mixtures listed in the Materials section above contain at least two classes of chemical.

Hazards:
You will need to learn the possible exposure routes, time frame and symptoms of NCNC hazards. Through the negligence of other lab members, you may be exposed to any of these at any time, so keep a watchful eye for trouble. Processes at NCNC regularly use chemicals in volumes sufficient to kill. Key words are bolded or italicized, and will appear throughout this SOP and others.
Chemical hazards at NCNC have three plausible routes: Inhalation, Contact and Explosion.

Inhalation hazards cause harm when breathed. Inhalation hazards primarily arise from materials that evaporate quickly (*high vapor pressure*), from the steam of boiling chemicals (*entraining*), and from plumes of mist (*aerosols*) created when mixing water into acids or bases. You will be able to smell any of NCNC's inhalation hazards before they reach hazardous levels, but some inhalation hazards can quickly anesthetize your nose so you can't smell (see Anesthetics below). No personal protective equipment (*PPE*) at NCNC will protect you from inhalation hazards, so if you notice an inhalation hazard your only available safety is to hold your breath and leave the area[1]. Working over plenums[2] will help prevent inhalation hazards from ever reaching you, like a fume hood would. Lastly, some NCNC equipment uses large amounts of toxic gasses from cylinders, but these gasses are difficult to expose yourself to. Gas sensors monitor most of these gasses, and a dedicated gas alarm will sound when they detect a leak.

Contact hazards cause harm when touched or splashed by. The most common forms of contact are caused either from chemical *residues*, from being careless around unknown chemicals, or from splattering/mist caused when pouring and mixing chemicals[1]. The hazardous residues left by chemicals can look like water, white crystals or even be invisible. Your mandatory white nitrile gloves will protect you from any invisible residues, but you can still burn yourself by touching a contaminated surface and then touching your face. In addition, to prevent spreading residues never touch common surfaces (doors, phones, etc.) while wearing heavy chemical gloves. Finally, some chemicals can soak through NCNC provided PPE, often without marking the PPE in the process (*PPE Penetrators*). The PPE SOP[1] discusses habits to mitigate this risk, and discusses the few PPE penetrator hazards that cannot be avoided.

Explosions are rare but still a risk. They are typically caused by one of these three routes[5]:
1. Tightly capping waste oxidizers** bottled for disposal ('bottle pops')
2. Mixing organics into oxidizers**, or using the wrong plastic tweezers (like Delrin or Celcon) in oxidizers.
3. Opening several year old bottles of '*peroxide former*' organics. Notify NCNC staff if you see such bottles.
** The most common oxidizers at NCNC are Hydrogen Peroxide and Nitric Acid.
Chemical hazards at NCNC have three plausible time frames: Acute, Chronic and Sensitizer[1,5].

Acute Hazards will hurt you immediately after exposure or up to a day later. Typically, they burn, but they can also poison. Acids, bases, oxidizers and fluorides all tend to exhibit acute hazards[1].
Chronic Hazards will harm you eventually, sometimes years after exposure. Though even small amounts can be harmful, the effect isn't bad enough to be noticeable until years after exposed, or until many small exposures have accumulated. Chronic hazards in massive doses often become acute hazards. Organics most often present chronic hazards.
Sensitizers will harm you only after repeated exposures (often over many years), and are harmless in the meantime. NCNC's Nitrile gloves are sensitizers, as are many organics[1].
Chemical hazards at NCNC have many ways they can harm you. The common mechanisms are: Anesthetic, Carcinogenic, Corrosive, Paralysing, Skin Penetrators, Toxic, and Teratogens.
Anesthetics remove your ability to feel or smell a chemical as it burns you, making them extremely dangerous. If your nose ever tingles from inhaling a chemical you may lose your sense of smell and should leave the area. If you notice 'water' on yourself and there's any possibility it's a fluoride (an anesthetic), treat it as such[1,2].

(Continued…)

(Cont.)

Carcinogenic hazards will greatly increase your likelihood of cancer. They tend to be chronic hazards and don't show symptoms until its too late, making it very difficult to determine if you're being exposed. The best defense against carcinogenic materials is to consistently wear the right protective equipment[1] and to build careful working habits[35].
Corrosive hazards (aka Caustic in some cases) will burn your skin upon contact, often terribly. Corrosives are all acute hazards, so symptoms appear within 24 hours and often begin with a painful tingle or rash.
Paralyzing agents make it very difficult to breath and in extreme cases can cause cardiac arrest. They tend to be acute.
Skin Penetrators will quickly absorb into your skin and through your body. They aren't necessarily hazardous on their own, but this property massively amplifies other hazards. Also, anything dissolved in a skin penetrator will be able to diffuse into your body much more readily.
Toxic hazards (aka poisons) will disrupt one of your internal organs, inducing sickness.
Teratogens, or developmental toxins, will only harm you if you're pregnant or nursing, but don't otherwise have ill effect in adults. NCNC commonly uses many extremely devastating teratogens, so if you're expecting or unsure, please ask for advice and ask a colleague or NCNC staff to perform your teratogen chemistries.

NCNC supplies many highly flammable liquids, often in squirt bottles.
Flammables will readily ignite by spark or flame. Because flammable organics are very common at NCNC the only way to avoid fires is to avoid creating sparks and flames. To that end, avoid bringing in electric equipment unless you can verify it's spark free. Fortunately, the high airflow at NCNC typically prevents flammable gasses from accumulating to explosive levels, especially over the plenums.

NCNC also presents a few non-chemical hazards: UV light, laser light, extreme temperatures, and sharps.
UV Light is generated by various machines at NCNC, and can damage your eyes. For NCNC's UV sources you would need to look directly at the source or work around it for a couple minutes to become noticeably injured. All NCNC UV sources also create a bright white, cool blue, or dim purple light while they are active. NCNC provides eye protection for working around these tools. Users will also post signs around hazardous UV sources when activated.
Laser Light is also produced by various machines at NCNC, and can damage your eyes. Most lasers at NCNC are low power and visible, which limits the likelihood of hazardous exposure.
Extreme Temperatures are present on samples coming out of furnace and anneal systems, and can be as high as 1000C. These temperatures will readily ignite tekwipes and solvents, and can burn you through metal tweezers. When working with these tools, you should wear thermal gloves provided by NCNC and avoid flammable organics. Hotplates and ovens can also become quite hot (400C) and should be treated with similar care when used at these temperatures. Extreme cold (*cryogenic*) temperatures are present at NCNC in certain pumps and tanks, but are nearly impossible to expose yourself to.
Sharps commonly include broken glassware, razor blades and syringes. Because these are so common at NCNC, sharps are a common source of minor injury. For more information see the Sharps SOP[4].

Chemical Exposure Actions: Do what's below, and then notify NCNC staff within a few hours. For advice, call NCNC Staff.
Eyes: Hold eyes open in running eyewash station for 15 minutes and call 911 as soon as possible.
Skin (non-Fluoride Chemicals): Remove splas-hed clothing, wash for 15 minutes and seek medical aid if irritation persists.
Skin (Fluorides): Remove splashed clothing, wash for 3 minutes, apply Calcium Gluconate gel and call 911.

Personal Protective Equipment[1]:
If approaching an unknown chemical, you need to wear protective equipment for any possibility. Wear goggles, a face shield, heavy chemical gloves (black Butyl/Viton)[1], and a heavy chemical apron. The outer layer of the black gloves will break down in some materials at NCNC, but the inner layer will protect you from any of these. Keep an attentive nose out for inhalation hazards, because no personal protective equipment at NCNC will protect you from these.

Additional Process Notes:
Following is a selection of 8 common chemicals at NCNC, and the hazards they present. These were chosen from hundreds of chemicals at NCNC to represent what you might come across in a typical day- they are not the most hazardous materials you might come across. For more information, most of the following chemicals (and many others) have dedicated SOPs already available at NCNC. Also, never forget that the NCNC staff is happy to work with you for learning chemical awareness.

Sulphuric Acid (H_2SO_4) is an acid, an acute contact corrosive, and leaves persistent wet residues. In addition, it is a PPE penetrator when undiluted.

Hydrochloric Acid (HCl) is an acid, an acute contact corrosive, and an acute inhalation hazard.

Potassium Hydroxide (KOH) is a base, an acute contact corrosive, and leaves persistent crystalline residues.

Hydrofluoric Acid (HF) is an acid and a fluoride. It's a devastating acute contact toxin, an acute contact corrosive, a chronic contact toxin and an acute inhalation hazard. It's also a skin penetrator and an anesthetic. For its breadth of hazards and anesthetic properties, HF is one of the most dangerous chemicals at NCNC.

Tetramethylammonium Hydroxide (TMAH) is a base, a chronic carcinogen, and an acute paralyzing agent. At NCNC's concentrations, it's a mild contact corrosive.

Acetone is an organic, a skin penetrator, and a very mild chronic inhalation toxin. It is exceptionally acutely hazardous when it contacts the eyes, and exceptionally explosive when mixed with oxidizers[3].

Dimethyl Sulphoxide (DMSO) is an organic, an exceptional skin penetrator, and a very mild chronic contact toxin. It is unfortunately a devastating teratogen.

Nitric Acid (HNO_3)[3] is an acid and an oxidizer. It's an acute contact corrosive, an inhalation hazard and can explode when mixed with organics or when improperly stored for disposal.

Haz Waste Management

Process:
Once finished with a hazardous chemical, you will need to dispose of it by aspiration, decanting or bottling. Aspirate whenever possible! You will also need to rinse clean any empty or nearly empty chemical bottles. For hazardous solids, you can discard in the Haz Waste bucket or Sharps bucket.

Aspiration

(Suctioning away chemicals)

Materials:
Waste inorganic liquid chemicals like acids, bases and fluorides. Water for rinsing.

Incompatible Materials:
No organics like solvents, strippers, or the TMAH common in developers. No toxic "heavy" metals like Chrome or Aluminum ions. No concentrated Sulfuric Acid or concentrated Acetic Acid, though these are ok if diluted by more than 5 volumes of water.

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOP. Aspiration creates little additional hazard.

Acceptable Locations For Use:
Wet process stations 3, 8, 9, acid & base fume hood[2].

Additional Process Notes:
Often the safest and most convenient option for chemical disposal, the aspirator is a plastic tube available at some benches that sucks chemicals to the neutralization system. If chemical is heated, allow it to cool beneath 45C[4]. Press the plenum[2] flush button to start the aspirator suction. Any material sucked into the aspirator will be flushed to NCNC's neutralization system along with many volumes of water. Submerge the aspirator tube into the bath, and hold it there until bath's contents have been removed as completely as possible. It is ok for the aspirator to 'slurp', though stop aspirating if you notice any splatter. At this point, rinse the bath with DI water and use the Aspirator to flush the water away- you may notice a puff of hazardous mist if too much chemical remained in the bath. Repeat water rinse and flush a few times, or until pH paper shows the bath to be clean. The aspirator is on a timer, so you may need to restart it by pushing the plenum[2] flush button again. Finally, give the bath a final rinse using a DI water gun over a sink to remove the last remnants of chemicals. To prevent spreading hazardous residues, always rinse off your gloves before leaving[1].

Decanting to Sink

(Pouring chemicals down the drain)

Materials:
Waste inorganic liquid chemicals like etchants or cleaners. Water for rinsing.

Incompatible Materials:
No organics like solvents, strippers, or the TMAH common in developers. No toxic “heavy” metals like Chrome or Aluminum ions. No toxic “heavy” metals like Chrome or Aluminum ions.

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOP. Take special care to not fumble your bath when decanting.

Acceptable Locations For Use:
Wet process stations 3, 8, 9, acid & base fume hood[2].

Additional Process Notes:
If chemical is heated, allow it to cool beneath 45C[4]. Run the sink’s water for 15 seconds. Carefully pour[3] the bath’s contents into the sink, while keeping your hands and face either protected or away from the sink in case of hazardous fumes[1]. Run water down the sink for another 30 seconds to dilute the chemical as it flushes away. At this point, rinse your bath with DI water and pour it down the sink as well- you may notice a puff of hazardous mist if too much chemical remained on your bath. Repeat water rinse a few times, or until pH paper shows the bath to be clean. To prevent spreading hazardous residues, always rinse off your gloves before leaving[1].

*Additional SOPs available, see: 1. PPE Choice and Cleaning 2. Work Station Use 3. Pouring and Mixing 4. Hotplates

Bottling

Materials:
Inorganic liquid chemicals like etchants or cleaners. Water for rinsing.

Incompatible Materials:
Any material can be bottled, though each individual bottle will have incompatibles[3].

Hazards, Exposure Actions and PPE:

Refer to chemical specific SOP. Bottling chemicals into the wrong accumulation bottle can cause explosions, fires, and violent eruptions of toxic fumes. Please ask us when in doubt! Expect heating if mixing concentrated chemicals into a spent chemical accumulation bottle. Never tightly cap waste bottles of oxidizers, even though they may generate toxic fumes. Tightly capping oxidizers with an improper cap can cause pressurization and an explosion.

Acceptable Locations For Use:
Bring spent chemical bottle to wherever your bath is. Most sinks are convenient[2].

Additional Process Notes:
Take care to choose the proper waste bottle for your process as choosing the wrong bottle can be deadly[3]. Your process' SOP will suggest the bottle in the Disposal section. You can also refer to the spent process materials flow chart for information on choosing the right bottle.
If your chemical is heated, allow it to cool beneath 45C[4]. Place waste bottle into a convenient sink, and insert a funnel. Carefully pour bath into the funnel. If any chemical spills out, keep pouring and rinse off the bottle when done[3]. At this point, rinse the bath with more DI water and pour it down the sink- you may notice a puff of hazardous fumes if too much chemical remained in the bath. Repeat water rinse and pour a few times, or until pH paper shows the bath to be clean. Rinse out funnel similarly. To prevent spreading hazardous residues, always rinse off your gloves before leaving[1].

Never tightly cap spent oxidizer bottles, or any other bottle you suspect might generate gas. Instead, leave the cap ¼ to ½ turn from tight.

Following is a list of common materials and what bottles they go in. If your chemical doesn't appear here feel free to prompt NCNC lab staff for advice. Acronyms can be found on NCNC's list of acronyms or with an internet search.

Aqueous Developers
MF-319 MFCD-26 AZ422

Flammables (important incompatibilities: no metal ions or organometallics)
PR Su8 developer Acetone IPA Methanol Toluene NMP DMSO PGMEA Chloroform Anisole Solid metals (lift off)

Organometalics (important incompatibilities: no solid metals)
Metal Ions Organometallics Silanes Spin-on-glass most adhesion promoters

Normal Fluorides (important incompatibilities: no strong acids / oxidizers)*
Metal ions HF BOE/BHF NH_3F

Aggressive Fluorides*
Metal ions HNA(mixed NH_4F, HNO_3 and Acetic acid) H_2O_2 HF HNO_3

Acetic Bearing Fluorides*
Metal ions HNA (mixed NH_4F, HNO_3 and Acetic acid)

Fluoride Strong Acid and Oxidizers*
Metal ions H_2O_2 HF HNO_3

Ordinary Acids* (important incompatibilities: no HNO_3, oxidizers or fluorides)
Metal ions HCl H_2SO_4 H_3PO_4 Acetic acid (mixed in water, not Glacial)

Acetate Bearing Acids* (important incompatibilities: no fluorides)
Metal ions Acetic acid PAN

Transiently Oxidizing Acids* (important incompatibilities: no fluorides)
Metal ions Piranha RCA2 H_2O_2

Persistently Oxidizing Acids* (important incompatibilities: no fluorides)
Metal ions HNO_3 SulphoNitric AquaRegia PAN

Ordinary Alkalis* (important incompatibilities: no oxidizers or fluorides)
Metal ions KOH NH_3 IPA H_2O Protek PR

Oxidizing Alkalis* (important incompatibilities: no fluorides)
Metal ions RCA1

* Best to aspirate or decant to neutralizer rather than bottling whenever possible. Only necessary to bottle if solution contains heavy metal ions or other un-neutralizable toxics.

Discarding to Haz Waste Bucket

Materials:
Waste solids and solids wetted with organic chemicals.

Incompatible Materials:
No Acids, Bases or Oxidizers. No Sharps[3].

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOP. Haz waste buckets create little additional hazard.

Acceptable Locations For Use:
Wet process stations 3, 8, 9, acid & base fume hood[2].

Additional Process Notes:
Open bucket and insert waste. Replace bucket lid when done. Notify lab staff when Haz Waste Bucket becomes full. Small amounts of dry photoresist are non-hazardous, so discard slightly used tekwipes in the normal trash.

Discarding to Sharps Bucket

Materials:
Sharp or shatter-able objects such as razor blades, glass, wafers, or syringe needles.

Incompatible Materials:
Avoid acids, bases or oxidizers, though tenth of a gram quantities are ok. Avoid organics, though gram quantities are ok.

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOP. Sharps buckets create little additional hazard.

Acceptable Locations For Use:
Specially labeled five gallon buckets on the floor of the photolithography bays.

Additional Process Notes:
Open bucket and drop sharps in. Replace bucket lid when done. Notify lab staff when sharps bucket becomes full.

*Additional SOPs available, see: 1. PPE Choice and Cleaning 2. Work Station Use 3. Pouring and Mixing 4. Hotplates

Bottle Rinsing

Materials:
Empty bottle with chemical residues to be cleaned.

Incompatible Materials:
Small bottles of resist will not easily rinse clean and should be discarded to the organics pass through or the haz waste bucket.

Hazards, Exposure Actions and PPE:

Refer to chemical specific SOP. Rinsing bottles creates little additional hazard. Concentrated acid bottles can create a small puff of fumes during the first rinse if insufficiently emptied.

Acceptable Locations For Use:
Any sink

Additional Process Notes:
If your chemical bottle is nearly empty after pouring from it, discard the rest of the chemical and rinse the bottle clean.

To clean a bottle, fill it partially with DI water, cap it tightly, shake it vigorously and then pour out the rinse water. Repeat 3-5 times. You can use pH strips to test the rinse water of acid and base bottles to help determine when you're done. After rinsing, remove the bottle's cap, cross out the bottle's label and re-label the bottle "Rinsed Clean" with a sharpie. Finally, you can find storage space for the rinsed clean bottle near the PPE storage.

Pouring and Mixing

Pouring

Materials:
Bottled chemicals, typically in the 1gallon plastic bottles provided by NCNC.

Incompatible Materials:
Refer to chemical specific SOPs.

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOPs. Pouring water into concentrated acid or bases will often cause splattering and fumes. Chemicals with vapor hazards are somewhat more hazardous as they are being poured. Pouring with the bottle's base out over your feet (instead of over the plenum) invites stray drips to splash on your poorly protected legs.

Acceptable Locations For Use:
Refer to chemical specific SOPs.

Additional Process Notes:
If your chemical bottle is nearly empty after pouring, discard the rest and rinse it clean[1].

Whenever possible, pour chemicals where you intend to use the bath. When pouring into a waste bottle, put the waste bottle in a sink and use a funnel to help. To pour, use two hands to hold the bottle, typically one at the bottle's neck and the other at its base. To prevent splattering, try not to let the chemical glug out as you pour, instead pour slowly enough that the chemical comes out in one steady stream. Make certain the bottle's base hangs over the bench as you pour, and not over your feet. Should the bottle dribble and drip it is much better to drip on the bench than on your feet.

After pouring a photoresist, clean off the bottle's threads using tekwipes dampened with acetone. These tekwipes can typically be discarded in normal trash. After pouring a concentrated acid, base or oxidizer, cap the bottle and briefly rinse off the outside of the bottle with DI water to remove any hazardous material that dribbled down the side of the bottle while pouring. After rinsing, briefly dry the bottle so others don't mistake the wet bottle for a chemical leak. Alternatively, if careful inspection reveals that no chemical dripped on the bottle while pouring, you can skip rinsing.

*Additional SOPs available, see: 1. Haz Waste Management

Mixing

Materials:
Chemicals to be mixed.

Incompatible Materials:

Refer to chemical specific SOPs. However, in general avoid mixing chemicals from these different classes: Oxidizers, Organics (reducers), Acids and Bases. Some mixtures will create heat, toxic gasses, or explosives.

Hazards, Exposure Actions and PPE:

Refer to chemical specific SOPs. Mixing compatible chemicals correctly creates little additional hazard. Mixing acids and bases creates heat and can splatter chemicals from floor to ceiling. Mixing oxidizers and organics can form explosive solids or highly flammable liquids. Mixing oxidizers with acids or bases often powerfully amplifies the oxidizer's reactivity and creates toxic gasses and explosives. Mixing organics with acids or bases occasionally makes 'condensate' gunk. Many of these mixtures are dangerous, but still used in the cleanroom.

Acceptable Locations For Use:
Refer to chemical specific SOPs.

Additional Process Notes:
If your chemical bottle is nearly empty after pouring, discard the rest and rinse it clean[1].
Mixing Solids into liquids: To avoid clumping and promote dissolution, mix a small amount of liquid into the solid and stir vigorously; then pour the solution into the rest of the liquid and stir again.

Mixing liquids: When mixing concentrated (>10%) aqueous chemicals (such as acids, bases and oxidizers), always pour the more concentrated solution into the less concentrated one to avoid splattering. This common rule has two convenient mnemonics:

1) (AAA) Always Add Acid to water.
2) (Boston Accent) Do as you oughta add acid to watta.

Though we suggest you always follow this rule, some institutions instead suggest mixing less concentrated oxidizers into more concentrated acids. The concentrations of chemicals provided by NCNC allow either order of mixing.

After pouring the liquids together, stir for about 20 seconds with an appropriate stir rod (Teflon is always acceptable). Mixing concentrated solutions takes longer than most people expect, especially when mixing water with 'oily' liquids, such as Potassium Hydroxide, Acetic Acid or Sulphuric Acid. Also, expect the solutions to exotherm (heat up) upon mixing.

Typically, no special rules need to be followed when mixing organics with organics.

*Additional SOPs available, see: 1. Haz Waste Management

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Labeling Experiments or Bottles

Process:
Labeling chemicals to be left for 5 minutes or overnight.

Materials:
Chemicals in a bath, beaker or bottle

Incompatible Materials:
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Hazards, Exposure Actions and PPE:
Unlabeled chemicals are a constant risk for NCNC staff, so please label your chemicals consistently. The highly toxic BOE is nearly indistinguishable from water without a label.

Acceptable Locations For Use:
Refer to chemical specific SOPs.

Additional Process Notes:
A good chemical label should include the following: The chemical name, and your name. If you plan on leaving the chemicals for more than 5 minutes, you should also include the date, your phone number (or email) and when you will return. If the chemical is particularly hazardous, make sure to represent this on your label. Though you can always use the full name of a chemical, you can also use a common acronym provided it's easily internet searchable or on our list of acronyms. Baths and beakers can be labeled with a nearby paper, tek wipe, or even directly on the beaker. Label baths and beakers accordingly:

NMP (Solvent)
Jane Doe 9/10/11
530-752-2241
I'm around the lab gathering supplies

Hydrofluoric, Acetic and Nitric Acids
(Very hazardous! Do not approach.)
Dirk Pitt Tue (May 5?)
530-752-2241
Overnight bath will clean up tomorrow (wed) morning.

Labels on bottles used for long-term chemical storage should include the above information minus your return time which is assumed to be one year after the present date.

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PPE Choice and Cleaning

PPE for Lab Entry

Materials:
NCNC provided cleanroom nitrile gloves, NCNC provided (or ANSI approved) safety glasses, and user provided closed toed shoes.

Incompatible Materials:
Refer to chemical specific SOPs. NCNC provided cleanroom nitrile gloves are permeated by acetone, most resists, most strippers, some acids and some bases. NCNC provided safety glasses will permanently fog on contact with Acetone.

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOPs. When walking through the lab you will face several potentially dangerous but unlikely hazards. Grossly malfunctioning equipment can throw shrapnel, which is primarily hazardous to the eyes. Hazardous chemical residues left on common surfaces can cause rash and severe irritation on hands. Residual chemical droplets on processing benches can drip down, making the feet a vulnerable target. If you suspect your hand has been exposed to chemicals through your gloves, take especial care to wash under your fingernails when washing for 15 min.

Acceptable Locations For Use:
Standard PPE can be used anywhere and on any equipment in the lab. However, it will not be sufficient for working with most chemicals.

Additional Process Notes:
ANSI approved safety glasses provide protection from both flying shrapnel and spray solvents (like acetone) which can be very damaging to the eyes. When safety glasses become smudged, feel free to clean them using spray bottle Isopropanol and a Tekwipe. Wipe gently as the tekwipes can scuff most plastics. If you need to see around the safety glasses and conditions are safe, you may temporarily lift the glasses higher on your head. Removing the safety glasses completely often leads to forgetting to replace them. ANSI approved safety glasses or goggles must be worn at all times in the cleanroom, regardless of whether you already wear prescription eyewear. NCNC provides ANSI approved safety glasses, though you can provide your own if desired.

White nitrile cleanroom gloves do not provide appreciable protection to most liquid chemicals, though they will provide protection to many hazardous residues throughout the lab. Keep in mind that your gloves may pick up hazardous residues while working, and avoid touching your face.

PPE for non-acutely hazardous Organics

Materials:
In addition to Lab entry requirements also wear black, inside-out Butyl/Viton gloves.

Incompatible Materials:
Refer to chemical specific SOPs and/or Ansell's glove choice guide from *www.**ansellpro**.com*. The black Butyl/Viton gloves have very few incompatibles and provide immersion protection against almost all chemicals provided by NCNC. However, some chemicals (aromatics, chlorosolvents, alkanes) will degrade the outer layer.

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOPs. Occasional, small splashes of NCNC's organics will cause relatively little harm, though small consistent (Chronic) exposures can vastly increase your likelihood of poisoning or cancer. Most of our solvents are not acute hazards, but can be potent carcinogens.

Acceptable Locations For Use:
Organics PPE can be used in any chemical bay and should never be used to press buttons on equipment for risk of spreading contaminants. However, if the PPE is clean you can use your knuckles to push buttons.

Additional Process Notes:
Wear the black Ansell Butyl/Viton gloves inside out, and rinse them off after use to keep them clean. These gloves are very expensive, so if you're working messily with photoresist, please wear disposable nitrile gloves over the black Viton/butyls. These gloves have two layers- when you correctly wear them inside out, the outer layer is butyl rubber, and the inner layer is Viton. This gives excellent resistance to most strippers, thinners and resist, as well as splash resistance to most other organics. On the off chance you instead want excellent resistance to aromatics (toluene), chlorosolvents or alkanes, you may flip the gloves right-side-in. However please make sure to thoroughly wash/scrub them, dry them, and flip them back inside out when you're done. These gloves naturally smell lightly of solvents.

Spray bottle solvents and resist spinners can splash and spray solvents which are hazardous to the eyes, so make sure to wear safety glasses or goggles when working with these.

NCNC provided face masks will not protect you from vapors so use solvents in the well-ventilated solvent workstations.

PPE for acutely hazardous
Acids, Bases, Oxidizers and Fluorides

Materials:
In addition to Lab entry requirements also wear blue Nitridex disposable gloves, a chemical apron and a face shield. Goggles are preferred to safety glasses for most applications.

Incompatible Materials:
Refer to chemical specific SOPs and/or Showa's glove choice guide from*:* http://www.newpig.com/wcsstore/NewPigUSCatalogAssetStore/Attachment/documents/ccg/N-DEX_PLUS.pdf . The blue disposable Nitridex gloves provide immersion protection against most aqueous chemicals provided by NCNC. However, they will only provide splash protection to concentrated (>40%) Sulphuric or Acetic acid (or undiluted cocktails of these chemicals like Piranha). Also, many organics will readily permeate the blue gloves.

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOPs. In general, our acutely hazardous chemicals are hazardous enough to cause painful burns from just a drop, so you should exercise great care even when wearing the appropriate PPE. Your feet will be particularly vulnerable to drops, so you must wear closed toed shoes. If splashed with acutely hazardous chemicals, typically you should remove any contaminated clothing first, use a safety shower for 15 minutes and call 911.

Acceptable Locations For Use:
Acid/Base/Oxidizer/Flouride PPE can be used in any chemical bay, but should never be used to press buttons on equipment for risk of spreading contaminants. However, if the PPE is clean you can use your knuckles to push buttons.

Additional Process Notes:
The blue gloves are disposable- at the end of your work day, just rinse off your gloves and discard them in the normal trash. These gloves can stand several re-uses, but by consistently using new gloves you can help reduce the risk of re-using a holey glove, or tracking someone else's chemical residues around the lab. These gloves give minutes of resistance to most aqueous chemicals, but are only splash resistant to concentrated (>40%) Sulphuric acid and Acetic acid. If you need better resistance, let us know, and we can set you up with an alternative. These gloves are naturally a little tacky.

Vinyl aprons provide excellent protection to most chemicals at NCNC, though you should inspect them for residues before use. Also, if you remove a vinyl apron after wearing it for an extended period, the built-up sweat may make it feel like you've splashed your arms

The face masks are size-adjustable and cleanable with Isopropanol. We stock replacement windows, so please tell us when the windows become overly smudged.

PPE for photolithography

Materials:
In addition to Lab entry requirements you may opt to wear a second pair of white nitrile gloves instead of the standard black, inside-out Butyl/Viton gloves. This is called 'double gloving'.

Incompatible Materials:
Refer to chemical specific SOPs. Besides alcohols, almost all solvents can permeate the cleanroom standard Nitrile gloves. However two pairs will provide limited splash resistance to photoresist and acetone.

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOPs. Occasional, small splashes of photoresist will cause relatively little harm, though small consistent (Chronic) exposures can vastly increase your likelihood of poisoning or cancer. Keep in mind, acetone and photoresist will readily permeate the white gloves, so strip off your outer glove quickly (within 10 seconds) if you suspect you've been exposed. If you suspect your hand has been exposed, take especial care to wash under your fingernails when washing for 15 minutes.

Acceptable Locations For Use:
Double gloving can be used in any chemical bay, and can be used on equipment and buttons provided the gloves are kept clean.

Additional Process Notes:
For performing photolithography or develop, experienced lab members can opt to double glove with our standard thin white nitrile gloves. This provides additional dexterity, necessary for some projects. Check the hands of your gloves for photoresist contamination before touching anything outside the photolithography bay (like the phone or door handles). Both pairs of gloves should be discarded when exiting the cleanroom.

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Sharps

Process:
Using and discarding sharps for standard cleanroom procedures. Cleaning broken glass and wafers.

Materials:
Razor blades, syringes, scalpels, chipped wafers, broken glassware and others.

Incompatible Materials:
When possible, try to avoid contaminating sharps with hazardous chemicals as it makes them more difficult to discard.

Hazards:
Many cleanroom sharps such as razor blades have extremely fine edges, which can create deep, clean, bloody cuts (incisions) on the hands. If sharps are contaminated with hazardous compounds (like photoresist), they can expose you to the material.

Exposure Actions: Do what's below, and then notify NCNC staff within a few hours. For advice, call NCNC Staff.
Eyes: Very rare due to mandatory shop glasses. Call 911. If sensible, apply gentle pressure with a trauma pad or gauze.
Skin: When possible grab another user to help you dress the wound in the gowning area, however when necessary you may dress your wounds in the cleanroom. Gauze and trauma pads are available in first aid kits located in the main office, gowning area, 1246 and the cleanroom safety stations. For deep cuts from a razor blade you can use the following advice:
If the cut lets a lot of blood, use gauze/trauma pad and gentle pressure to soak away blood, replacing the pads as needed. - If bleeding does not remit, call 911. - If bleeding continues very slightly, use a butterfly bandage to hold the cut closed, wrap the area with plenty of gauze and tape the gauze in place with slight pressure. Replace the gauze regularly. - If bleeding stops, apply antiseptic to a bandaid or the surrounding skin (do not apply antiseptic into a cut), and apply bandaid. Your cut will likely need stitches if the cut is deeper than a couple millimeters or bleeds for more than 5min. Your cut may be infected and will require medical attention if it becomes red, swollen, itchy, hot, rashed, smelly, oddly uncomfortable, red-lined, or discharges puss. Though tetanus is unlikely in a cleanroom, always defer to your doctor's advice.

Acceptable Locations For Use:
Sharps are common and allowed throughout the cleanroom[2].
Additional Process Notes:
When cutting with unmounted blades, always double check which side is the sharp side, and make sure your other hand is far away from the cut path in case of slips. When using syringes, beware their impressive ability to slash and cut. The edges of chipped wafers are sharp enough to cut, though rarely do when properly handled. Discard any waste sharps in the sharps bucket[6]. Except for shop glasses, none of the NCNC PPE is designed to protect you from sharps. That said, heavy chemical gloves can somewhat reduce the risk of cuts from broken wafers and glass wear. When in doubt, ask the lab staff to help with handling broken glassware.

*Additional SOPs available, see: 1. PPE Choice and Cleaning 2. Work Station Cleaning 3. Pouring and Mixing 4. Hotplates 5. Hydrofluoric Acid 6. Haz Waste Management

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Work Station Use and Cleaning

Process:
Using plenums (also called work stations or chemical benches) for various chemistries, and cleaning after use.

Materials:
Plenum tops and labware to be used and cleaned.

Incompatible Materials:
- none -

Hazards, Exposure Actions and PPE:
Refer to chemical specific SOPs. Cleaning a plenum or labware of a chemical does not introduce significant additional hazards. DI spray guns might splatter contaminated cleaning water back at you, so make sure to wear appropriate eye protection.

Acceptable Locations For Use:
Any plenum may be cleaned in this way

Additional Process Notes:
Each plenum comes equipped with a DI faucet for washing, a DI spray gun for rinsing, and Nitrogen gun for drying samples. Many plenums additionally come equipped with a sink, dump rinser, a solvent strip bath, sunken chemical baths, plenum flushes and cleanroom squeegees.

Plenum are made of a high density polypropylene immune to all NCNC provided chemicals including aggressive acids, oxidizers and organics. So when you do spill or dribble chemicals onto the plenum, you can take your time to cautiously clean it. To clean a plenum, alternate between spraying the plenum with a DI water gun, and squeegeeing the rinse water down the holes in the front or back of the plenum. Water and small amounts of chemicals can be rinsed and squeegeed directly down the holes in the plenum top where they will flow to the sanitary sewer or NCNC's acid and base neutralizer depending on the location. When in doubt, four or five quick repetitions of spraying and squeegeeing will clear away most small spills or residues. For acids and bases, you can also use pH paper provided by NCNC to check the pH of your rinse water.

To maximize your safety from chemical residues, rinse off your plenum as above before using it each time. If confronted with questionable solids or residues you can use NCNC provided pH paper to determine the nature of the residue. For testing solid, dry samples, first wet the pH paper with DI water. For more information on pH paper and its uses, talk to NCNC lab staff.

To rinse off samples, use the DI water gun and hold the sample with a pair of tweezers over the sink or even over the plenum top if you intend to squeegee away the rinse water later. You can alternatively use the inset dump rinsers to rinse large numbers of wafers clean all at once. Dump rinsers are controlled by an On/Off button on the front face of the plenum. NCNC dump rinsers are programmed to rinse through three cycles when run.

*Additional SOPs available, see: 1. Haz Waste Management