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Experiment Safety Review Form
Review Number: NC-07-2011

PRINCIPAL INVESTIGATOR: Aaron Stein
GROUP: NC
EXT: 3527 **E-MAIL: stein@bnl.gov** **LIFE NUMBER: 22947**

Project Title: Nanoscale Patterning and Characterization
Location(s): 0735
Area(s): 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46
Proposed Start Date and Duration: 12/1/2010 - 1 years

SIGNATURES:

Principal Investigator: Aaron Stein	**Date: 3/25/2011**
Experiment Review Coordinator: Robert Sabatini	**Date: 4/18/2011**
Reviewer: Frank Zafonte	**Date: 2/3/2011**
Reviewer: Deborah Bauer	**Date: 3/23/2011**
Reviewer: Lorraine Davis	**Date: 3/15/2011**
Reviewer: Nicole Chiu	**Date: 2/18/2011**
Approval: Emilio Mendez	**Date: 4/18/2011**
Review/Approval (ERC) Comments: 04/18/2011 2:02 PM 03/15/2011 12:33 AM Debbie I updated the information you noted. There is no liquid He used.	
Walkthrough Signature: Robert Sabatini	**Date: 4/15/2011**
Expiration Date (max 1 yr.): 4/18/2012	
FUA Change Required? No	
Fire Rescue Run Card Changes Required? No	
Has a NEPA Review been Performed for this Project? Yes	
Required Approvals (i.e., IACUC, IBC, etc.): NA	

Project Termination Acceptance Signature: **Comments:**	**Date:**

I. Define the Scope of the Work

A. Description

Introduction

Nanofabrication Technology is used to fabricate nanoscale patterns in a variety of materials; this work includes nanomaterial electric/optical devices, x-ray gratings and optics, photonic devices, etc. This work is done in support of science at the CFN and BNL at large as well as the CFN external user community. Primary fabrication steps include lithography of resist materials via electron beam, ion beams, UV radiation and nanoimprint lithography. Additionally, fabricated samples are examined by optical and scanning electron microscopy (SEM) as well as measured by optical profilometry.

This ESR mainly covers the nanoscale patterning and characterization capabilities in the clean room. The thin film processing (e.g. thin film deposition and etching" are covered in NC-08-2010.

The clean room is a limited access room maintained under positive pressure to provide a Class-1000 (1L-44 and 45) and Class-100 (1L-46 & 47) environment. Everyone entering the clean room area is required to "suit up" – i.e. put on a clean room coverall, a head covering, shoe covers and boots and nitrile gloves **at all times**. *The proper procedure for clean room gowning is described in SOP-NC-2007-ELM-OPS-1.*

Samples specimens may involve nanomaterials and users will read and consult the Interim Procedure for Nanomaterial Handling found in SBMS. Nanomaterial samples to be imaged by SEM or used in any fabrication processing will have already been put into a fixed form (i.e., fixed to a surface or otherwise immobilized and prevented from aerosolizing) following the Interim Procedure prior to being brought into the laboratory.

Waste

There are multiple satellite accumulation areas (SAA) in the laboratory. SAA's each for flammable waste and corrosive waste are located in between the hoods in 1L-46, there are also SAA's in dedicated waste cabinets for flammable and corrosive wastes under the tables in 1L-46. In addition, there is a dedicated SAA only for piranha waste which is located under the hood in 1L-46. Solid waste for resist-coated materials (e.g. pipettes, foil, wipes, gloves) goes into a dedicated red trash can in 1L-46. All of these areas are clearly labeled as SAA's. Wastes are strictly segregated into three types: flammable/solvents; acids; bases and particular care is made to ensure that waste maintains segregated.

All waste bottles are also clearly labeled, both with a traditional BNL hazardous waste label and an additional tag tied around the bottle neck. The tag has both the chemical name on it as well as an identification number. Since there are a large number of users generating waste in the laboratory, we use common waste bottles. There is a common log book for logging the waste added to each bottle. Users note in the log book their name, date, the chemical, the quantity and the bottle number of the bottle they've added the waste to. New waste bottles are generated only by CFN clean room staff members. Filled bottles are removed only by clean room staff members.

When disposing of waste, users must take bottle from SAA and put in the hood – waste should not be poured into bottles while they are still in the SAA. Funnels are provided for pouring waste into waste bottles. If a waste bottle is filled, users should inform CFN clean room staff.

***Piranha waste** is of particular concern both for the potential for violent reactions upon contact with organic materials as well as over-pressurization of the waste vessel. Piranha waste is isolated from all other wastes to prevent any confusion or mixing of chemical types. It is kept in a special clear poly-coated glass container to prevent shattering with a special pressure-relief cap. These caps are white and a supply of them is kept in the clean room.*

Operation

Photoresists *are applied to substrates (silicon or silicon dioxide on silicon,quartz, etc.) by spin-casting using a spin coater and baked on a hot plate which is connected to the spin coater or in an oven. During spinning, the substrate is placed on the chuck and the photoresist is deposited by pipette or filtered syringe; the substrate is held to the chuck by vacuum and the chuck is spun by a motor at speeds of 1000-5000 RPM. There are two spin coaters, both located in 1L-46. The* Brewer CEE *coater is located in a laminar flow fume hood. The* Suss *spinner is a standalone unit which is exhausted by snorkel. Each spinner requires vacuum – used to hold samples down on the chuck during spinning or on the hot plate during baking -- and compressed air used only for valve pneumatics. For each, the house air and vacuum supply are used. Photoresists used during spinning are always in solution and are stored in either the manufacturer's container or poured off into properly labeled glass bottles when smaller quantities or different solution strengths are required. Safety glasses with side shields as well as a face covering are required when spinning photoresists. In addition, each spinner has a cover to prevent splattering of resist material during spinning – the systems are interlocked such that they will not spin unless the covers are closed. Run-off resist goes down a drain which is collected as hazardous waste. The Suss spinner has a special canister for effluent resist material which is wired to alarm when it is full; the system will not operate unless the canister is emptied. Anything that comes in contact with photoresist (e.g. wipes, pipettes, foil) are collected in a specially marked red waste can. Waste resists will be considered hazardous waste. A liner of aluminum foil will be used around a plastic bowl in the Brewer spinner to collect waste resist and will be routinely changed; the used foil will be bagged and labeled as hazardous waste and moved immediately to the nearest satellite accumulation area. Used syringes will be collected in a standard yellow non-medical-waste sharps container. There is a detailed standard operating procedure (this SOP needs a number?) for use of the spinners and hotplates with further details about the available resists and the processing parameters.*

The ***nanoimprinter*** *in 1L-46 is an* Imprio 55 *manufactured by Molecular Imprints. This tool uses a patterned quartz template to emboss a pattern into a dispensed monomer solution which is then cured by ultraviolet radiation into an exact daughter replica of the master pattern on a silicon substrate. The monomer solution is stored in very small quantities (<100 mL) in glass canisters attached to the machine. It is dispensed in droplets on the order of <1nL at a time. The monomer is a proprietary material consisting of an acrylic ester, hydrocarbon acrylate as well as a crosslinking agent and a photoinitiator. The MSDS for this material (Monomat) is attached to this document. The main hazard associated with the monomer is skin contact which is unlikely during normal operation. The only time such contact might occur is during the changing of the monomer reservoir (once every 3-5 years) or during the unlikely event that one of the nozzles needs to be cleared of some particulate blockage. In these instances, service will be done only by trained individuals who will be sure to wear gloves (double gloves recommended) which will be removed and bagged immediately after the service is completed.*

The UV source is a commercially available 200 W lamp completely contained within the machine, at the back of the tool; the heat from the lamp assembly is exhausted out through a duct on the back of the unit. The lifetime of the bulb is monitored internally and after 2000 hours of use, it will automatically become inactive, forcing a bulb change and avoiding the potential of a bulb explosion. The system is interlocked against UV exposure: the system will not operate if the UV-blocking front door is opened; additionally, the system will shut down if any of the panels are removed. The imprinter requires vacuum to hold the wafer and template; the vacuum is provided by a scroll pump located in the service chase – the pump oil will be changed every year. The pump is left off when the system is not in use and is powered by a switch inside the clean room. In addition, house compressed air is used for pneumatics valve manipulation. Helium gas is used to purge air from the dispensed monomer. After some use, the imprint templates require cleaning through a prescribed reclaim procedure which involves cleaning with Pirhana etch: sulfuric acid and hydrogen peroxide. The procedure to operate the nanoimprinter is included the tool manual located electronically on the PC of the tool itself. An additional manual is on Aaron Stein's PC and can be transferred electronically to all new users to familiarize themselves with the apparatus.

There are two UV ***mask aligners*** *in the clean room that have similar hazards associated with them: the Karl Suss MA-6 and Karl Suss MJB3. The MA-6 has a 500W Hg-Xe lamp which requires a vented housing to capture the ozone generated when the lamp is illuminate. The MJB3 a UV source with a sealed Hg lamp. The aligner requires house vacuum for holding samples on the stage during exposure. There are no other hazards associated with these instruments.*

The JEOL JBX-6300FS ***electron beam lithography*** *instrument is located in room 1L-47. This instrument uses 100kV electrons to pattern electron beam resist on the nanoscale. The tool has a minimum feature size of 8nm, a field size of 1 millimeter and a deflector speed of 50MHz. The system has an autoloader interlock with room for 10 cassettes. Presently the CFN has 5 cassettes for pieces, 3" wafers, 4" wafers, 4" masks and 65mm imprint templates. There is a detailed standard operating procedure for the basic use of the JEOL e-beam tool. (this SOP needs a number has well)*

This tool has both high pressure nitrogen for pneumatics and low pressure nitrogren for system venting. Both are provided by the nitrogen generators located in the service galley. The system has its own water chiller which is cooled by house chilled water. The system has a high voltage tank generating 100kV electrons. The tank and the electron beam column are insulated with SF_6 gas which is totally contained within the system. A Users interaction with the tool is entirely with the computer system controlling the instrument which is totally interlocked to prevent any dangerous or undesirable conditions. There are no other hazards associated with this instrument. There is a dedicated hood in 1L-47 for loading and unloading samples. There are dedicated tweezers only for use in loading and unloading samples. These tweezers are labeled with green tape and should not leave the hood area in 1L-47.

*The dual beam **focused ion beam/scanning electron microscope** (FIB) is an FEI Helios NanoLab located in room 1L45. The FIB will be used both for sample characterization as well as nanopatterning. The FIB uses a focused beam of gallium ions to pattern a material by direct etching or cutting. The tool also employs a beam of focused electrons in a standard SEM configuration that is used both for patterning electron beam resists as well as imaging and characterization. Additionally, the Helios is outfitted with an x-ray detector for spectroscopic characterization of samples.*

The FIB requires nitrogen gas supplied from a compressed gas bottle in the chase for venting the chamber. It also uses compressed air (house) for pneumatic valves. A water chiller in the chase supplies necessary cooling water to the unit. A dry rotary vacuum pump is also located in the service galley to provide vacuum to the FIB. Additionally, precursor gas sources (e.g. platinum) in small quantities are attached to the FIB and are introduced into the vacuum environment and then deposited on samples using ion-beam or electron-beam induced deposition.

FIB/SEM sample specimens will be prepared and mounted on a sample stage on a table located in room 1L45. The sample specimens consist of thin material films or fabricated features on rigid substrates, typically silicon or glass. These are mounted onto a tool sample holder using either mechanical spring clips, double-sided carbon tape, or in some cases silver paint. Samples are patterned or imaged with the FIB operating at accelerating voltages between 0.1 and 30kV. The Oxford x-ray detector also requires cooling by LN2. A procedure for filling the LN2 vessel is contained in SOP-NC-2007-ELM-Cryo-3. Tool operators will wear appropriate PPE and respect the hazards of LN2 when performing this operation. Required PPE is (1) cryogenic gloves, (2) face shield, and (3) safety glasses with side shields or safety goggles; since all people inside the clean room must wear a clean room coverall, there is no additional requirement for lab coat or long sleeves.

The procedure to operate the FIB is included the tool manual located electronically on the PC of the tool itself as well as in hard copy inside the cabinet in room 1L45.

The metrology area of the lab (1l-44) includes multiple pieces of equipment. There are two profilometers, one using white light interferometry and one stylus-type, which are used to measure sample topography and step heights of thin films. There is an ellipsometer and an optical microscope. 1L-44 also contains a diamond scriber for cutting silicon wafers into smaller chips.

The hoods also contain various hot plates as well as a constant temperature bath for chilling chemicals down to -15C. Proper care must be taken when doing any thermal processing, particularly when heating chemicals.

All work with chemicals will be done inside the hoods in room 1L46 except for resist spinning when using the Suss standalone unit. Chemical processes include baking and development of resists, etching with acids (e.g. chromium etchant) and bases (e.g. potassium hydroxide) and solvent cleaning. MSDSs are used to evaluate material hazards and special handling requirements. Full listings of chemicals used under this ESR, including waste handling and controls can be found below in sections I.B. and III. Chemicals used include photoresists and imprint resists which are used in small (<mL) quantities at a time. Most of the resist material ends up adhered to a substrate like silicon or quartz and thus very small amounts of waste are generated. Most resists are flammable and may also be irritants. Resists used in the clean room include optical photoresist Shipley S1800 series, SU-8, PMMA, ZEP-520A, MA-N and HSQ. Standard solvents – acetone, methanol, isopropanol, ethanol – are used for both cleaning of samples and glassware, for dilution of resists, as well as in various processing steps. Resist developers include flammable materials such as xylenes and bases like TMAOH or NaOH. Refer to the chemical list below for more details.

Since all work in the clean room will require users to be "suited up," all users of chemicals will be covered in their clean room coverall and will be wearing nitrile gloves. Safety glasses with sideshields will also be required. In addition, acids will be handled only when wearing elbow-length rubber gloves and appropriate face shield. Other acids used in etching include nitric acid, sulfuric acid and hydrochloric acid. Potassium hydroxide is occasionally used to etch silicon.

*When chemicals are not being used, they will be stored in the appropriate cabinets inside the clean room area, except for small spray bottles of solvents (*i.e. *acetone*, *isopropanol, methanol) which may be kept in secondary containment inside the hood. In addition, some chemicals, particularly photoresists will be stored in a flammables refrigerator inside 1L46.*

***All** compressed gases,* i.e. *high purity O2, N2, Ar, and He, for these operations are stored in the service chase alongside the back of the clean room.*

The nanoimprinter (Molecular Imprints) and the FIB (FEI)) are maintained under service contract with the vendor. The maintenance work performed by the vendor will comply with the requirements set forth in the SBMS "Work Planning and Control for Experiments and Operations."

The clean room is equipped with an emergency exhaust system which can be activated in the case of a hazardous chemical spill. There is a HEPA-filtered vacuum located in the gowning room for general cleaning maintenance as well as potential clean up of particulates. A spill kit is located on the chemical cabinets in the clean room.

Equipment manuals or procedures that are controlled documents:

- Several equipment manuals are electronic and kept on the computers associated with the tool. These include manuals for:
  - JEOL 6300FS
  - Helios Dual/Beam including
    - NPGS
    - Inca detector
  - Nanoimprinter
  - Profilometer
- Manual for SUSS spin coater is kept in cabinet underneath the system
- SOP's have been written by nanofabrication staff for:
  - Clean room gowning
  - Clean room protocols
  - Acid use
  - MJB 3 use
  - JEOL6300 user
  - Resist use: spinning/baking
  - Helios start-up
  - Liquid nitrogen filling of Inca detector

B. Human Performance Factors

1. Acid use is of particular concern in the clean room. We restrict use of acids to only approved Users. To become authorized requires additional training, both from CFN staff and from the industrial hygienist. In addition, an SOP has been written specifically to deal with the hazards involved with acids.
2. Waste disposal is also a major concern in the clean room. SAA's are segregated and kept in clearly labeled and isolated areas of the room. Waste bottles are labeled multiple times and numbered to force Users to pay attention to make sure the waste bottle matches the waste they are disposing. Only CFN staff generates waste bottles to ensure that only approved chemicals are being used.
3. With the Helios system, the major fear is that a user could accidentally hit the SEM pole piece with their sample. The system is well safeguarded against this, so it is rare, but there are a couple instances where this might happen, particularly if the system computer has some glitch occur. We try to prevent this possibility through vigilant training of all system users that if anything is to happen with the computer to contact a CFN staff member before proceeding.
4. Because there are so many different people using the clean room facility, there is potential for housekeeping issues to arise that can give rise to working conditions that are both unsafe as well as inefficient. Again, through the use of an SOP on clean room use and protocol, training and leading by example, we have significantly minimized this issue. CFN staff cleans and tidies 1L-46 every Monday to ensure that this does not become a safety concern.

C. Waste Minimization/Pollution Prevention

The smallest amount of solvents is always used during development and sample processing. Whenever possible, developers are used multiple times before discarding to minimize hazardous waste.

The Suss spinner is specially engineered to allow for proper thicknesses to be spun by using the minimal amount of photoresist necessary, which will allow us to prevent unnecessary waste of these materials. Similarly, the nanoimprinter uses advanced dispensing capabilities (w/ picoliter resolution) to deliver only the amount of material necessary with no waste accumulated at all. The imprinter also allows for precise flow and pressure control on the helium required to make sure that the smallest amount is used for each imprint to conserve this resource.

The FIB utilitizes an oil-free vacuum pumping system to eliminate this source of hazardous waste (i.e., spent pump oil).

All images are captured and stored digitally to minimize paper usage.

We will use lint-free cloths as work surfaces during sample preparations with each cloth serving multiple uses prior to disposal.

Empty glass bottles and broken glassware are collected for disposal.

Clean room garb is used several times before recycling unless it has been contaminated with hazardous materials in which case the garment will be collected and bagged, marked appropriately and placed in the nearest satellite accumulation area.

D. Materials Used /Waste Generated

Materials Used	Disposal Method	Amount per Use	Amount per Year	Comments
see attachment		0.00	0.00	
		0.00	0.00	

II. Identify and Analyze Hazards Associated with the Work

The following hazards were identified:

Physical Hazards:

- Sharps (non medical)
- Cryogens (any substance or device capable of producing temperatures <= 170K)
  (Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46)
- Compressed gases (lecture bottles, cylinders, gas lines)
  (Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46)
- Compressed gas-Flammable
  (Area: 0735-FIRST-1-1L44)
- Compressed gas pyrophoric
  (Area: 0735-FIRST-1-1L44)
- Compressed gas-toxic
  (Area: 0735-FIRST-1-1L44)
- Compressed gas-highly toxic
  (Area: 0735-FIRST-1-1L44)
- Flammable liquids
  (Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46)

Chemical Hazards:

- Chemicals, Hazardous (General)
- Carcinogens

(Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46)
- Corrosives
- Piranha Etch/Corrosive Etching Solutions
- Flammable liquids
  (Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46)
- Peroxidizables
  (Area: 0735-FIRST-1-1L45)
- Hydrofluoric acid, any use
  (Area: 0735-FIRST-1-1L44)
- Nano-material bound in a solid matrix or fixed substrate
  (Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46)
- Unbound NanoParticulate (UNP) in a suspended liquid or dry particulate state
  (Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45)
- Toxic metals (e.g., As, Ba, Be, Cd, Cr, Hg, Pb, Se, Ag)
  (Area: 0735-FIRST-1-1L44)

Ionizing and Non-ionizing Radiation Hazards:

- Radiation generating devices- exempt
  (Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46)
- Class 1M, 2/2M,3R lasers
  (Area: 0735-FIRST-1-1L45)
- Ultraviolet sources >1 W
  (Area: 0735-FIRST-1-1L44)

Biological Hazards:

- None

Offsite Work:

- None

Other Issues (Security, Notifications, Community, etc.):

- None

Significant Environmental Aspects

- Any amount of hazardous waste generation
  (Areas: 0735-FIRST-1-1L44, 0735-FIRST-1-1L45, 0735-FIRST-1-1L46)
- Any amount of industrial waste generation (e.g., oils, vacuum pump oil)
- Production or use of, or waste containing, engineered nanomaterials
- Any atmospheric discharges that require engineering controls
  (Area: 0735-FIRST-1-1L44)
- spill potential (Other)

III. Develop and Implement Hazard Controls and Assess Risk

A. Physical Hazards, Tasks and Controls

Hazard, Default Controls, Task Specific Info	Risk Level
Hazard: **Sharps (non medical)** **Default Controls:** Sharps including needles, razor blades and syringes (plastic and glass) must be disposed of in sturdy, rigid, sharps containers. Sharps containers cannot be more than 2/3 full.	**Negligible (0-20)**
Hazard: **Cryogens (any substance or device capable of producing temperatures <= 170K)**	**Negligible (0-20)**

Default Controls:
General Requirements:
• Evaluate location oxygen deficiency
• Store/transport only in approved containers (i.e. DOT/ASME or BNL LESHC)
• Never pour from above chest level
• PPE: Long Sleeve Shirt (or Lab Coat), long pants (or skirt covering ankles) and closed shoes

Pressurized transfer to open (vented) container; Or-Pouring > 5 liter volumes of LN2 between open containers:
• Face shield along with either Safety Glasses (w/side shields) or Goggles
• Gloves (Cryo or Heavy Leather)

Pouring small (5 liters or less) volumes of LN2 between open containers:
• Safety Goggles (face shield recommended if possible)
• Gloves (Cryo or Heavy Leather)

Work with samples immersed in LN2 in small (~1 liter) dewars:
• Use Tongs (tools) to manipulate/handle cryogenic samples (do not touch with gloves)• Use insulated non-absorbent gloves with dexterity (cotton/nylon gloves under disposable nitrile gloves)
• Safety Goggles

Task Specific Info:

liquid nitrogen

Hazard: **Compressed gases (lecture bottles, cylinders, gas lines)** — **Negligible (0-20)**

Default Controls:
• Any systems >15psi must be SME Approved
• Transport cylinders using a cylinder cart
• Secure cylinders to a fixed object/wall
• Use regulator, hoses, and components compatible with gas
• Use hoses and clamps rated for maximum regulator output or use pressure relief device
• Wear safety glasses with side shields when installing/removing/or adjusting regulator
• Label piping/tubing

Task Specific Info:

N_2, O_2, Ar, gases stored in tanks with appropriate low-pressure regulators. Compressed gas training required.

Hazard: **Compressed gas-Flammable** — **Acceptable (21-40)**

Default Controls:
In addition to compressed gas requirements:
• Flash arrestor/backflow device
• Separate 20 ft from oxidizers or barrier
• Electrically ground lines/equipment
• Non-Sparking tools

Task Specific Info:

Hydrogen, methane

Hazard: **Compressed gas pyrophoric** — **Negligible (0-20)**

	Default Controls: Controls specific to task required. **Task Specific Info:** silane	
Hazard:	**Compressed gas-toxic** **Default Controls:** Controls specific to the task are required. **Task Specific Info:** ammonia	**Negligible (0-20)**
Hazard:	**Compressed gas-highly toxic** **Default Controls:** In addition to compressed and toxic gas controls: • Need to be used with a gas cabinet • Separate at least 20 ft. from flammable or pyrophoric gases or install a metal barrier Controls specific to the gas and task are required. **Task Specific Info:** chlorine, hydrogen bromide, silicon tetrachloride, boron trichloride	**Acceptable (21-40)**
Hazard:	**Flammable liquids** **Default Controls:** As for chemicals, plus Store large quantities in Flam. cabinets as required **Task Specific Info:** Resists, Methanol, Acetone, and Isopropanol used in fume hood only. No open flames or sparks involved. Nitrile gloves, safety glasses with side shields worn when using chemicals.	**Negligible (0-20)**

B. Chemical Hazards, Tasks and Controls

	Hazard, Default Controls, Task Specific Info	Risk Level
Hazard:	**Chemicals, Hazardous (General)** **Default Controls:** • All operations with large (>250ml, health hazard 3) quantities of hazardous chemicals (pouring, mixing, evaporation, etc) in hood, or use snorkel when hood is impractical • Register Commercial Chemicals in CMS • Work alone after hours only if permitted by supervisor or ESR • Identify containers so contents are identifiable unless being actively used (ex. 1 shift) • Food, beverage, smoking, and cosmetics are prohibited • Handle glassware properly: no mouth suction, no drinking from labware.	**Negligible (0-20)**
Hazard:	**Carcinogens** **Default Controls:** Use hazardous chemicals controls plus: Establish and post a "designated area" where used	**Acceptable (21-40)**

Note location on fire run card and hazard info. placard.
Exposure monitoring to assure that action levels not exceeded
Establish procedures for work area cleanup and decontamination

Hazard: **Corrosives** — **Negligible (0-20)**

Default Controls:
Use hazardous chemicals controls plus:
- Unobstructed access to Emergency Eyewash and Shower

Task Specific Info:

Are handled using appropriate gloves, lab coats, eye protection, and hoods. Eye washes available. See hydrofluoric acid info below.

HF

All work involving HF will be performed in a fume hood in 1L-46. We clearly label all chemicals containing HF. Full protective gear, including elbow-long neoprene gloves (as splash protection), protective upper body gown, and face shield will be worn at all times when handling HF. Adequate containers (polyethylene or Teflon) will be used for handling and storage of HF solutions, and work with HF will always include a means of spill prevention/protection. A HF emergency kit will be kept inside the laboratory located next to the designated hood. When working with HF and other concentrated acid, we follow the procedure described in the Standard Operating Procedure: **SOP-NC-2007-OPS-CHEM-1 (HF)**.

Hazard: **Piranha Etch/Corrosive Etching Solutions** — **Negligible (0-20)**

Default Controls:
• Use smallest amount possible.
• Work in hood behind a sash.
• This material is very reactive (exothermic).
• Avoid organics. It will explode if mixed with organics!
• Before wasting the solution you must allow it to Cooldown for 24 hours or longer uncovered in a hood.
• When there is no more gas generation, it must be wasted into a clear poly-coated waste bottle equipped with a venting cap. The waste bottle must have the special label indicating Piranha Etch/Corrosive Etchant. (Note: Corrosive etchants containing HF must be stored in plastic bottles
• It is recommended to segregate Piranha etch/Corrosive Etchants from other wastes.
• Never place Corrosive Etching Solutions in an airtight container—they will over-pressurize and may explode!

PPE:
Safety glasses with side shields or goggles
Labcoat, closed toed shoes, long pants.
Face Shield (or hood sash) when mixing.

Hazard: **Flammable liquids** — **Negligible (0-20)**

Default Controls:
Use hazardous chemicals controls.
Review large quantity storage with Fire Protection Engineer
Note location on fire run card and hazard info. placard for storage of solids, greater than 40 pounds; liquids, greater than 5 gallons; gases, greater than 10 pounds

Hazard:	**Peroxidizables** **Default Controls:** Use hazardous chemicals controls plus: Identify class and label based on CHP List A substances test every 3 months Lists B, C test every six months Before designating as waste, assure testing current (if testing is not possible contact ECR)	**Acceptable (21-40)**
Hazard:	**Hydrofluoric acid, any use** **Default Controls:** Use hazardous chemicals controls plus: • HF burn kit (training on use by SHSD rep) • Location of HF to be entered on Fire Run Card and Hazard Information placard • Designated area for HF use and storage must be Posted. • Two people must be in speaking/hearing range at all times that HF is in use. • Off-hours use generally prohibited. Must be approved by OMC Mgr. and Chem Hygiene officer • HF storage in its own secondary containment • PPE: as for corrosives plus: • PPE: Face shield for >2% solutions (1 molar). or if high splash potential. • HF resistant apron (typ. thick butyl rubber or neoprene) • Spill cleanup: <10ml in fume hood can be neutralized with Calcium carbonate or hydroxide • Spill cleanup: >10 ml or any amount outside hood: evacuate and call 2222. • Any worker exposure report to OMC.	**Negligible (0-20)**
Hazard:	**Nano-material bound in a solid matrix or fixed substrate** **Default Controls:** PPE Requirements for Handling: Standard PPE required for the work area. No additional requirements. Handling Requirements • No Mechanical abrasion. • No thermal stresses. • No etching Laboratory Posting Requirements - No Posting Requirements Waste Handling: • Solids containing nanomaterials which have a potential to be released must NOT be disposed in the regular trash. See SBMS Hazardous Waste Management for more information. • Collect solid UNP waste in a bag (6 mil thick minimum zip-lock type or J-sealed) or other sealing container (i.e. jar with threaded lid). • Spell out the chemical name (do not use formulas or trade names) on the RED Hazardous Waste Label. • The contents line on the label must contain the chemical composition and the word “NANO” • A second label, in addition to the Red Hazardous Waste Label, is required on the outside other container/bag stating “CONTAINS NANOMATERIALS” see ES&H Coor. or 90-Day area manager for labels.	**Negligible (0-20)**
Hazard:	**Unbound NanoParticulate (UNP) in a suspended liquid or dry particulate state** **Default Controls:** PPE Requirements for Handling: Standard PPE required for the work area plus: • Gauntlet-type nitrile gloves “or” wrist length disposable nitrile gloves with extended sleeves and labcoat. • Eye protection: Safety glasses with side shields for handling powders only. Chemical splash goggle for handling large quantities of liquids or powders that could become airborne.	**Negligible (0-20)**

Handling Requirements Must be manipulated within a HEPA filtered laboratory exhaust hood, glove box, glove bag, or other ap	
Hazard: **Toxic metals (e.g., As, Ba, Be, Cd, Cr, Hg, Pb, Se, Ag)** **Default Controls:** As for chemicals, plus need for SHSD and OMC monitoring and surveillance must be evaluated BURF for Beryllium operation	**Negligible (0-20)**

C. Environmental Hazards, Tasks and Controls (include on/off site transportation and products/services)

Hazard, Default Controls, Task Specific Info	Risk Level
Hazard: **Any amount of hazardous waste generation** **Default Controls:** Engineering Controls • Waste will be accumulated in chemically compatible containers that appropriately contain/protect the waste. • Waste containers will be closed in a tray (secondary containment) in the Satellite Accumulation Area (SAA). Administrative Controls • All hazardous waste containers will have a (red) “Hazardous Waste Label” that has the generator’s name and the chemical contents (trade name/formula not acceptable). • All waste will be accumulated in closed containers and kept in an established and posted SAA until ready for transfer to the 90-Day Haz Waste Area for pick-up by Waste Management. • For pick-up by Waste management, complete the Nonradioactive Haz Waste Control Form and consult the 90-Day Area Manager to gain access/transfer the waste to the 90Day Area. Training: Hazardous Waste Gen. (HP-RCRIGEN3). PPE: When handling waste materials follow PPE requirements specified for the specific materials. Comply with the SBMS Subject Area: “Hazardous Waste Management”. **Task Specific Info:** • If the Hg lamps in the mask aligners crack or break releasing the Hg vapor, evacuate the area and call x2222.	**Acceptable (21-40)**
Hazard: **Any amount of industrial waste generation (e.g., oils, vacuum pump oil)** **Default Controls:** Engineering Controls • Store only compatible wastes together, in suitable containers. • Provide secondary containment for liquid wastes if potential for environmental release exists. • Keep containers closed and secured unless adding waste to container. Administrative Controls • Use a green industrial waste label, with generator’s name and chemical contents (trade name/formula NOT acceptable). Label oils “Used Oil”. • When full, complete and submit a WCF for pick up. The waste may be stored in the 90-day	**Negligible (0-20)**

area.

Training: Hazardous Waste Generator (HP-RCRIGEN3)

Comply with the SBMS Subject Area: “Industrial Waste”.

Task Specific Info:

- Used pump oil is industrial waste unless contaminated with other substances. If contaminated, the contaminates must be identified on the waste label and on the waste control form.

Hazard:	**Production or use of, or waste containing, engineered nanomaterials**	**Negligible (0-20)**

Default Controls:
• All waste in contact with nanomaterials must be disposed as hazardous waste e.g., (gloves, lab coats, swabs, Kimwipes, blotter paper, beakers, flasks, tape, sample holders). Chemicals containing nanomaterials must NOT be released to the sink or disposed in the regular trash. See SBMS Hazardous Waste Management for more information.
• Liquids must be stored in a rigid leak proof container.
• Particulates must be stored in a rigid leak proof containers “OR” =/> 6 mil plastic bags.
• Spell o

Task Specific Info:

Label with "Nanomaterials Label" in addition to the red hazardous waste label.

Hazard:	**Any atmospheric discharges that require engineering controls**	**Negligible (0-20)**

Default Controls:
• Maintain controls and emissions according to permit requirements, if applicable.
• Maintain control equipment (such as filters) as per manufacturer’s recommendations if not a permitted emissions point.
Comply with the SBMS Subject Area: “Nonradioactive air emissions”.

Task Specific Info:

Scrubber for RIE systems

Hazard:	**spill potential (Other)**	**Negligible (0-20)**

Default Controls:

Task Specific Info:

- Follow Spill response Subject area and section 7 of the Interim procedure “Approach to Nanomaterial ESH”. Call x2222 if spill is beyond workers training/skill to clean up. Spill control materials are located in the NW corner of the clean room.

Local Emergency Plan, Spill, secondary containment, hazardous waste satellite areas.

D. Radiation Hazards, Tasks and Controls

Hazard, Default Controls, Task Specific Info		Risk Level
Hazard:	**Radiation generating devices- exempt**	**Negligible (0-20)**

	Default Controls: If shielding is altered contact FSS for surveys prior to restart.	
Hazard:	**Class 1M, 2/2M,3R lasers** **Default Controls:** Administrative Controls • Complete registration form and laser use permit for laser(s), submit to Laser Safety Officer (LSO) • Contact LSO for posting requirements Comply with Subject Area “Laser Safety” **Task Specific Info:** System has been reviewed. With the controls it is now a Class 1 requiring no addtional controls.	**Negligible (0-20)**
Hazard:	**Ultraviolet sources >1 W** **Default Controls:** Task and source specific. Evaluate below.	**Negligible (0-20)**

E. Biological Hazards, Tasks and Controls
None

F. Offsite Work Hazards, Tasks and Controls
None

G. Other Issues (Security, Notifications to Other Organizations, Community Involvement, etc.)
None

H. Recommended Exposure Monitoring

- None

Description or comments:

I. EPHA Determination

Chemical Name	Quantity (lbs, gal)	Location (Bldg/Room#)

IV. Perform Work Within Controls

A. Recommended Training and Medical Surveillance Summary

- Laboratory Standard (HP-IND-220)
- Cryogen Safety (HP-OSH-025)
- Hazardous Waste Generator (HP-RCRIGEN3)
- Nanoparticles Protocol (OM-MEDSURV-NANO)
- Compressed Gas Safety (TQ-COMPGAS1)
- Nanotechnology for Nano-workers (TQ-NC-HS2)

B. Personnel Training, Qualification, and Authorization List

Employee/Guest Name	Life/Guest#	Dept	Required Training Course(s)	Signed
Aaron Stein	22947	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 3/2/2013]	

			Laboratory Standard (HP-IND-220) [EXPIRES: 2/28/2013] Nanotechnology for Nano-workers (TQ-NC-HS2) [EXPIRES: 6/4/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 4/11/2012] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: EXPIRES: NEVER]	
Don Elliot	14624	IO	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 3/6/2013] Laboratory Standard (HP-IND-220) [EXPIRES: 7/20/2012] Nanotechnology for Nano-workers (TQ-NC-HS2) [UNASSIGNED: EXPIRES: 5/8/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 3/18/2012] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: EXPIRES: NEVER]	
Fernando Camino	23799	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 3/4/2013] Laboratory Standard (HP-IND-220) [EXPIRES: 8/24/2013] Nanotechnology for Nano-workers (TQ-NC-HS2) [EXPIRES: 4/29/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 8/17/2012] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: EXPIRES: NEVER]	4/13/2011 3:10:09 PM
Chuck Black	23566	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 2/12/2013] Laboratory Standard (HP-IND-220) [EXPIRES: 11/15/2012] Nanotechnology for Nano-workers (TQ-NC-HS2) [EXPIRES: 6/4/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 11/15/2012] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: INCOMPLETE]	
Ming Lu	24188	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 4/8/2012] Laboratory Standard (HP-IND-220) [EXPIRES: 4/11/2013] Nanotechnology for Nano-workers (TQ-NC-HS2) [EXPIRES: 4/30/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 4/7/2012] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: EXPIRES: NEVER]	5/11/2011 9:22:21 AM
Xiao-Liang Wang	24139	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRED: 2/23/2012] Laboratory Standard (HP-IND-220) [EXPIRES: 2/14/2013] Nanotechnology for Nano-workers (TQ-NC-HS2) [	

			EXPIRES: 5/4/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 1/25/2013] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: EXPIRES: NEVER]	
Danvers Johnston	24305	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 8/5/2012] Laboratory Standard (HP-IND-220) [EXPIRES: 8/2/2013] Nanotechnology for Nano-workers (TQ-NC-HS2) [EXPIRES: 8/7/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 8/3/2012] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: EXPIRES: NEVER]	
Chang-Yong Nam	23659	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 3/4/2013] Laboratory Standard (HP-IND-220) [EXPIRES: 5/27/2013] Nanotechnology for Nano-workers (TQ-NC-HS2) [EXPIRES: 4/27/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 3/8/2012] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: EXPIRES: NEVER]	5/2/2011 10:37:28 AM
Kim Kisslinger	24192	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 4/30/2012] Laboratory Standard (HP-IND-220) [EXPIRES: 4/20/2013] Nanotechnology for Nano-workers (TQ-NC-HS2) [EXPIRES: 5/1/2012] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 4/20/2012] Nanoparticles Protocol (OM-MEDSURV-NANO) [UNASSIGNED: EXPIRES: NEVER]	
Ye Tian	V7771	NC	Cryogen Safety (HP-OSH-025) [EXPIRES: NEVER] Compressed Gas Safety (TQ-COMPGAS1) [EXPIRES: 2/7/2014] Laboratory Standard (HP-IND-220) [EXPIRES: 2/7/2013] Nanotechnology for Nano-workers (TQ-NC-HS2) [EXPIRES: 2/8/2014] Hazardous Waste Generator (HP-RCRIGEN3) [EXPIRES: 2/9/2013]	

C. Emergency Procedures

Following the Bldg. 735 Local Emergency Plan. Spill kits located in rear lobby and in 90-day area. Eyewash and shower in the cleanroom. In the event of a building emergency just walk out of the clean room. In the event of a normal building emergency just walk out of the clean room. **DO NOT DISROBE FIRST. In the event of a TOXIC GAS release. There will be a temporal 3 alarm followed by a message to exit out the north(front) doors only. After evacuation go to the outdoor assembly area on the west side of the building.**

D. Transportation

Samples are occasionally transported to/from the CFN. These are almost always non-hazardous nanofabricated samples, usually on silicon wafers or chips ranging in size from chips of several mm's to wafers up to 4 inches. Follow SBMS

Transportation subject area.

E. Logistical Interactions

Get to safe location Call x2222 or 631-344-222 from a cell phone Contatct ES&H Coor. Bob Sabatini @ x3509 or 631-294-0778 Notify Facility Leader/contact

F. Termination/Decommissioning

Closeout is not anticipated in the near future. At the time of closeout, guidance from ESH Coordinator, Facility Safety Representative, and Environmental Compliance Rep. will be sought.

V. Provide Feedback

Procedures for piranha etching, Cr, and Al etching have been developed. Waste SAAs have new segregation by type (acid, base, organic).

VI. Attachments

Attached Files:

Materials Used in CR ESR #8.doc

wet etch operator aid_r.pdf

rca-1 operator aid_r.pdf

HF Acid Operator Aid_r.pdf

aqua regia operator aid_r.pdf

Piranha Etch Operator Aid _2_.pdf