Center for Nanoscale Science and Technology

NIST National Institute of Standards and Technology

Nanofab Facility Cleanroom Laboratory Manual

1. INTRODUCTION

The NIST Center for Nanoscale Science and Technology (CNST) enables science and industry by providing essential measurement methods, instrumentation, and standards to support all phases of nanotechnology development, from discovery to production. It is composed of two groups. The Electron Physics Group has the mission of advancing measurement science for the determination of electronic and magnetic properties of nanometer-scale systems. The research areas are nanomagnetics, atomic scale characterization and fabrication, nanoscale measurement and fabrication using laser-controlled atoms, and modeling nanostructures in mesoscopic environments. The Nanofabrication Facility Group maintains and operates the Nanofabrication Facility, or Nanofab. It is operated as a national shared use Facility for NIST and external users, which includes both fabrication and characterization tools, as well as access to specialized measurement tools and expertise residing in NIST's extensive measurement laboratories. Most of the equipment in the Nanofab resides in the CNST Nanofab Cleanroom, which is the main subject of this usage manual.

The NIST CNST Nanofab has approximately 745 m^2 (8,000 sq-ft) of Class 100 bay and chase, cleanroom space with extremely wide Class 1000 equipment corridors. NIST has invested in a complete suite of new state-of-art semiconductor equipment (capable of processing 150 mm wafers and various sizes of samples) that includes:

- ATM furnaces (2 banks of 4 tubes each)
- LPCVD (poly, nitride, LTO)
- PECVD
- Rapid Thermal Annealer
- 4 Reactive Ion Etchers (SF_6/O_2, Metal RIE, Metal ICP, Deep Silicon)
- Microwave Asher
- Critical Point Dryer
- 5 Metal deposition tools (thermal, e-beam, sputter)
- 3 Contact Mask Aligners (front- and back-side alignment)
- 2 E-beam lithography systems
- Focused Ion Beam
- Nanoimprint Lithography
- Inspection (FE-SEM Zeiss Ultra 60)
- AFM
- Metrology Tools (Spectroscopic Ellipsometer, Contact Profilometer, 4-point probe station, Nikon Optical microscope with image capture, etc.).
- Wafer Dicing Saw

▪ *Note: for more details and an up to date equipment lists see the nanofab website at www.cnst.nist.gov.*

In addition to the cleanroom the nanofab operates additional equipment in separate rooms, also open to the users. This equipment listed by room number is as follows:

Nanofab Facility Equipment Outside the Cleanroom

Nanofab Tools	Building	Room Number	Contact
Wafer Dicing Saw	215	C02-2	Russ Hajdaj x2699
Focused Ion Beam #1 Focused Ion Beam #2	(Temporary) 217 216	G122 E102	Babak Nikoobakht x3230 Alex Liddle x6050
Wire Bonder	216	E111	Gerard Henein x5645
Atomic Force Microscope	218	C010 SB	Jabez McClelland x3721
Inspection Microscopes	218	C010 SB	Jabez McClelland x3721

The Nanofab will be operated as shared access user facility. This means that the staff of NIST and its partners, subject to provisions, training, and user fees, will be permitted to independently operate the equipment. The tools will be operated in a manner such that a wide variety of materials can be processed. The facility will be directed by NIST's Center for Nanoscale Science and Technology. Unlike other Nanofabs, the NIST CNST Nanofab is unique in that it is located next to the most advanced metrology tools in the world, and its focus will be on fabricating nanoscale structures necessary for metrology and standards in support of the semiconductor industry, nanotechnology, biotechnology, and homeland security.

This Cleanroom Usage Manual describes the organization and general procedures related to the facility. Section 2 describes the management of the facility and the types of facility users. Section 3 describes general procedures for using the facility including new user access, a description of the facility layout, facility governance, visitors, and publication policies. Section 4 describes cost structures and fees for using the facility. Section 5 describes policies associated with equipment including guidelines for operating procedure development and revision, equipment training, scheduling, modification, repair, installation, maintenance, consumables, and a description of equipment capabilities. There are separate manuals describing the operation of each individual tool. Section 6 describes general procedures associated with safety including responsibilities and authorities. A separate Safety Manual for the facility exists that describes safety issues in detail. Contact information for facility management and super users is given in the Section 7 Appendix. A facility web site (http://cnst.nist.gov) also contains a description of the facility.

2. ORGANIZATION

2.1 Organizational Structure of CNST

The CNST is an Operational Unit of the National Institute of Standards and Technology, in the United States Department of Commerce. CNST provides measurement methods, standards and technology to support all phases of nanotechnology from discovery to production; develops and maintains a national facility, the CNST Nanofab, with unsurpassed nanoscale fabrication and measurement capabilities; conducts long term research in measurement science to develop new measurement methods, standards and reference data and promulgates these methods, standards, and data by publishing, conducting workshops, and collaborating with industry, universities and other government agencies; applies multidisciplinary approach that involves partnering with industry, academia, and other government agencies, serves as a hub to link the external nanotechnology community to the measurement expertise that exists within the NIST Laboratories; maintains appropriate collaborations with other laboratories in NIST, the nation and throughout the world; helps to educate the next generation of nanotechnologist.

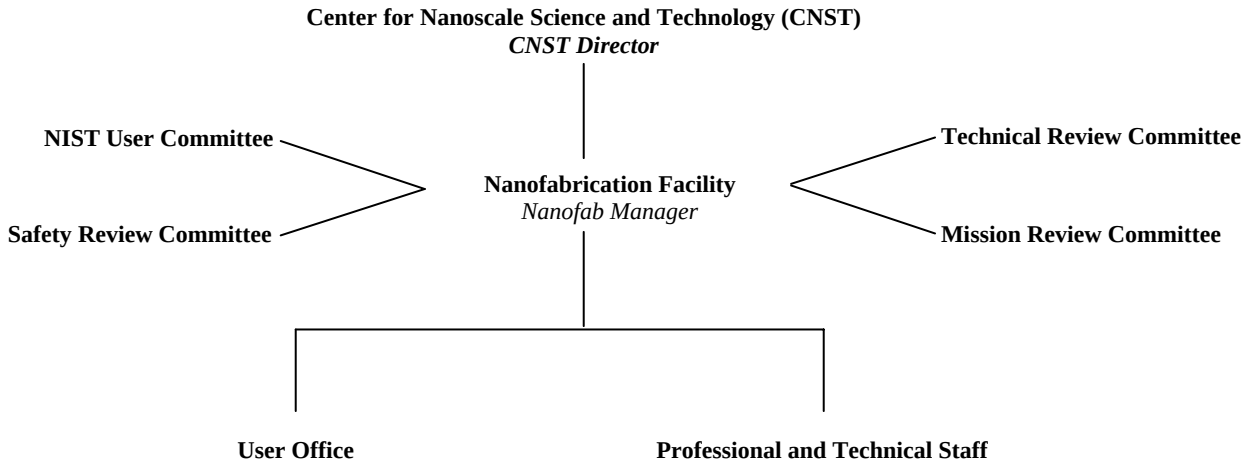
The CNST Nanofab is operated by the CNST Nanofabrication Facility Group. It provides access to state-of-the-art nanofabrication tools, technologies, and expertise in a shared-access, shared-cost environment to NIST and its partners; enables fabrication of prototypical nanoscale test structures, measurement instruments, standard reference materials, electronic and magnetic devices, MEMS, and bio-devices critical to the nation's nanotechnology needs; fosters internal collaboration in nanotechnology across NIST's laboratories; and fosters external collaboration in nanotechnology with NIST's partners.

The other group under the CNST is the Electron Physics Group. This group develops advanced electron probing techniques for nanoscale measurements such as scanning electron microscopy with polarization analysis (SEMPA) and scanning tunneling microscopy (STM); manipulates matter on an atomic scale with STM and fabricates nanostructures making use of the high degree of control provided by laser-atom manipulation; Investigates electron interactions with atoms, molecules, and condensed matter; determines the electronic and magnetic properties of surfaces, and develops and uses a range of theoretical techniques to study nanostructures and their connection with mesoscopic environments.

2.2 Organizational Structure of the Nanofab Facility

The Nanofab Facility Group consists of a user office, and a staff of process engineers and fixed operation technicians reporting to the Nanofab Manager. In addition, its mission of operating the nanofabrication facility is supported by a User Committee, Safety Review Committee, and two proposal review committees. The organizational structure is shown in figure 2-1 and the elements are described below. Contact information for Nanofab management is given in the Section 7 Appendix.

Figure 2-1 Organizational Structure of the Nanofab



2.2.1 Nanofab Manager

The CNST Nanofab is managed by the Nanofab Manager who reports directly to the CNST Director. He is formally responsible for all aspects of the operation and safety of the facility. The Nanofab Manager is the supervisor of the Nanofab Staff. The Nanofab Manager is responsible for the budget of the facility, outreach for the facility, and developing a user-base for the facility.

2.2.2 NIST User Committee

At its discretion, the Nanofab Manager will convene meetings of or ask for input from representative users via the NIST User Committee. This is a group of NIST users, outside of CNST appointed by the CNST director.

2.2.3 Safety Review Committee

The Safety Review Committee is an advisory committee that provides independent input and guidance on safety-related issues and incidents appointed by the CNST Director. The Safety Committee does not have line-management authority or responsibility related to safety. The Safety Committee will review the development of safety policies and procedures, review the development of and any major modifications to equipment and review the installation of any new equipment and their respective operating procedures. The Safety Committee will also review all safety incidents and may assist in preparing a report on the incident.

2.2.4 Technical Review Committee

The technical Review Committee is composed of the Nanofab Manager and two additional CNST employees appointed by the CNST Director. The Technical Review Committee will

provide technical reviews of the incoming proposals for safety, feasibility and usage issues, according to the following criteria.

1) Can the proposed project be carried out safely in the Nanofab? (refer to safety manual) Yes___ No___
2) Are appropriate tools available to carry out the project with a reasonable chance of success? Yes___ No___
3) Is it clear that the materials and processes proposed will not contaminate the facility or equipment? Yes___ No___
4) Is it clear that the tool usage for this project is within the Nanofab capacity and will not create bottlenecks for other projects? Yes___ No___

2.2.5 Mission Review Committee

The Mission Review Committee is composed of three members of CNST Staff, appointed by the CNST Director. The Mission Review Committee reviews proposals to determine their level of alignment with the CNST Mission, according to the criteria listed below. Scores are forwarded to the CNST director, whom determines if the project is eligible for a partial fee waiver.

1) Is the project non-proprietary? Yes___ No___
2) If yes, does the project support the CNST/NIST mission of providing measurement methods, standards, and technology to support all phases of nanotechnology development from discovery to production? (100 points total)
    a) Degree to which project advances measurement science, standards development and/or nanomanufacturing technology (50 points)
    b) Scientific and technical merit of application (20 points)
    c) Appropriateness of methods (10 points)
    d) Competence of personnel (10 points)
    e) Reasonableness of proposed budget (10 points)

2.2.5 Nanofab User's Office

The Nanofabrication Facility User office is the first point of contact for users' routine questions regarding access, security, accounting, and local information such as travel and accommodations.

2.2.6 Nanofab Professional and Technical Staff

The Nanofab is staffed by Process Engineers and Technicians who are responsible for the day-to-day operations of the Nanofab, for training users, and for operating the tools for remote users (at additional cost). In addition, they are also available for collaborations involving process development. The Nanofab Manager and Staff have immediate authority regarding all aspects of safety and operation in the cleanroom.

2.3 Users

There are currently three types of users for the CNST Nanofab Facility; Nanofab Users, Cleanroom Users, and Remote Users. This manual is intended to serve as a resource for the Cleanroom User.

2.3.1 Nanofab User

Nanofab users are persons certified to operate Nanofab equipment located outside the cleanroom. They are required to take the Nanofab orientation and training specific to the instruments they will be using.

2.3.2 Cleanroom User

Cleanroom users are persons who are certified to operate equipment located inside the cleanroom. In combination with the orientation, they receive additional training on cleanroom safety and cleanroom operational procedures. Before gaining access to the cleanroom they must pass a safety exam. They will also be required to take training specific to the instruments they will be using.

2.3.3 Remote User

Remote users are people who do not wish to operate the equipment themselves, but instead specify work to be performed by Nanofab Staff (at an additional hourly rate). They must still receive an orientation for the Nanofab.

3 CLEANROOM DESCRIPTION

The following section describes various locations within the Nanofab Cleanroom and rules regarding access by Certified Cleanroom Users. See Section 7.3 for the Facility Layout Map. See Section 3.8 regarding visitors.

3.1 Main Lobby-D101/Bldg.215

This room is the main entrance to the Nanofab Cleanroom; it is room D101 in bldg 215. This room is where the controlled environment begins. This room is certified as a Class 1000 clean area. This room has a card reader on the door and can only be accessed by authorized individuals and certified Cleanroom Users only.

3.2 Locker Rooms/Pre-gowning

There are men and women's lockers available for your personal belongings (hats, coats, cell phones, phone-cameras, PDA, notebooks, other). The locker rooms are used as the Pre-gowning areas for accessing the class 1000 corridor prior to entering main gowning.

3.3 Main Gowning Room

This room is for final gowning before entering the Class 100 cleanroom proper. Entry is made through the door marked "Entrance". Do not cross over to the clean area without full gowning apparel.

3.4 Cleanroom Work Bays

3.4.1 General Wet Chemistry Bay-B101

This bay is for all common chemistry work, not recommended for CMOS or Electronic device processing. Access to this bay is for all certified Cleanroom users.

3.4.2 Clean Silicon Wet Chemistry Bay-B102

This wet chemistry bay is dedicated to ultra-clean silicon processes. General chemistry work is prohibited and must be done in the general chemistry area. The Nanofab management and staff strictly enforce this policy.

3.4.3 Metrology Bay-B103

This bay is open to all trained and certified Cleanroom Users and is available on a first come first served basis.

3.4.4 FESEM Bay-A101

This bay is open to all certified Cleanroom Users who have been trained and authorized to use this equipment by the Nanofab Management.

3.4.5 Optical Lithography Bays (Photo 1 and Photo 2)-A102 and A103

Open to all certified Cleanroom users who have been trained and authorized to use this equipment by the Nanofab Management.

3.4.6 E-beam Lithography Bay-A104 and A101

Open to all certified Cleanroom users who have been trained and authorized to use this equipment by the Nanofab Management.

3.4.7 Metal Deposition Bay-B104

Open to all certified Cleanroom Users who have been trained and authorized to use this equipment by the Nanofab Management.

3.4.8 Dry Etch Bay-B105

Open to all certified Cleanroom Users who have been trained and authorized to use this equipment by the Nanofab Management.

3.4.9 Oxidation and Diffusion Furnaces and CVD Bay-B106, B107

Open to all certified Cleanroom Users who have been trained and authorized to use this equipment by the Nanofab Management.

3.4.10 Open Class 100 Bays-A105, A106

These bays are held as reserve space for future NIST partners or NIST collaborations related to nanotechnology.

3.5 Service Chases

Service chase areas contain mechanical, electrical and other ancillary equipment and are not to be accessed from the cleanroom proper by Cleanroom Users. Cleanroom Users can enter these areas from the Class 1000 corridors in order to place materials into the appropriate pass-through for retrieval from the cleanroom.

3.6 Sub-fab-215 Basement

This area is restricted, and can only be accessed by Nanofab staff and authorized NIST Plant personnel.

3.6.1 Hazardous Material Cut-Off Room-E05

Restricted and can only be accessed by the Nanofab Staff.

3.6.2 Chemical Storage-D106

Process chemicals are stored here. This room is restricted, Users may not enter

3.7 Phones-Cleanroom

Phones are located inside the cleanroom along the walls at the end of the bays near the center hallway.

3.8 Chemical Pass-thru

Air-lock pass-thru's are used for passing items (chemicals and other materials) into the cleanroom from the outside. Access to a specific pass-thru is done from the class 1000 corridor, and entering into the respective service chase for that particular pass-thru. Pass-thru's are labeled for Acid and Solvent materials.

3.9 Chemical receiving room-D107

This room is where the chemicals are received. They are brought up from the basement using the dumb waiter, wiped down, inventoried, and transferred into the two way chemical closets for storage in the chemical storage room.

3.10 Equipment Resources

This section includes a general description of the capabilities of each processing tool and includes what kinds of materials can go in each tool, wafer sizes, etc. The operating manuals for each tool are not a part of this document.

Tool	Sample Size	Capability	Restrictions	Tool ID	Bldg/Room #
Tystar ATM Furnaces	3", 4", 6" wafers	Wet/Dry SiO2, Diffusion, Solid source doping, Anneal	Tool C is for CMOS and Ultra clean silicon only!	B,C	215/B106
Tystar LPCVD	3", 4", 6" wafers	Polysilicon, Silicon Nitride, Low Temp Oxide	Silicon only	A	215/B106
Modular Process Technology RTP	4", 6" wafers	Rapid thermal Anneal. Forming Gas, Argon, Nitrogen, Oxygen		E	215/B105
Unaxis PECVD	Samples to 10" substrates	Low temp: Polysilicon, Silicon Oxide, Nitride	Silicon only	D	215/B106
Unaxis Silicon RIE	Samples to 10" substrates	Thin Film etching: SiO2, Poly, Nitride, Organics	Silicon only	F	215/B105
Unaxis Metal RIE-Fluorine	Samples to 10" substrates	W, Au, Cu		G	215/B105
Unaxis Metal RIE-Chlorine	Samples to 10" substrates	Al		J	215/B105
Unaxis Deep Silicon Etch	Samples to 10" substrates	Deep Silicon etching	Silicon only	I	215/B105
Xactix XeF2 Silicon Etch	Samples to 6" wafers	Isotropic silicon etching, High silicon selectivity		H	215/B105
Denton Thermal Evaporator	2", 3", 4" and 6" wafers	Al		K	215/B104
Denton Thermal and E-Beam Evap.	2", 3", 4" and 6" wafers	Au, Cr, Ti, Ni, Ag, Fe, Al, Cu		M	215/B104
Denton Sputter	2", 3", 4" and 6" wafers	SiO2, Au, Cr, Ti, Ni, Cu		O	215/B104
CVC Evaporator	3" , 4" wafers	Au, Cr, Ti, Ni, Ag, Co, Hf		L	215/B104
Myers Dry Evaporator	Samples to 6" wafers	Au, Ti, Al (Oil-free vacuum system)	Dedicated to Molecular Electronics research	N	215/B104
Woollam M-2000 Ellipsometer	Up to 6" wafers	Thin film measurement		P	215/B103
Nanometrics Nanospec	Samples to 4" wafers	Thin film measurement		Q	215/B103
Dektak 6M Profilometer	Samples to 6" wafers	Step height and stress analysis		R	215/B103
Rudolph Ellipsometer	Samples to 4" wafers	Thin film measurement		S	215/B103
Nikon Microscope	Up to 6" substrates	Inspection, image capture		Z	215/B103
4-point Probe station	Any size, up to three inches thick	Resistivity, doping measurements		AA	215/B103

JEOL 6400 SEM/E-beam	Samples up to 3" wafers	Inspection and lithography		V	215/A104
Suss MicroTec Contact Aligner-MA6/BA6	2" 3", 4" and 6" wafers	Lithography (0.75um) I-line, G-line, UV-400. Backside Alignment. Wafer-to-wafer bond alignment.	Avoid touching or moving backside scopes.	T	215/A102
Suss Microtec Contact Aligner-MA8/BA6	6" wafers	Lithography (0.75um) I-line, G-line, UV-400. Wafer-to-wafer bond alignment.		U	215/A102
HTG Mask Aligner	2", 3", 4" wafers	Lithography (1-2 um) I-Line, G-line		W	215/A103
Zeiss FESEM	Samples to 6" wafer	Inspection		CC	215/A101
Leica VB-300-UHR E-beam Lithography	Up to 6 " (300mm Capable)	10 Wafer Air-Lock, Resolution < 4 nm, Linewidth < 10 nm			215/A101
Disco 341 Wafer Dicing Saw	Small pieces to 8" wafers.	Silicon, Sapphire, Ceramic, Quartz			215/C02-2
PVA Tepla Microwave Asher	Pieces up to 25 8" wafers	Removes hard baked photoresist, SU-8, etc. Also release of MEMS structures without Stiction.	CF4 requires ceramic chamber		215/105B
Tousimis Critical Point Dryer	Up to 8" wafer	MEMS			215/102A
Focused Ion Beam	TBA	Milling, Deposition, Inspection, etc.	TBA		216/E102
K&S Wire Bonder		Au Wedge Bonder			216/E111
Atomic Force Microscope					218/C010
Inspection Microscopes					218/C010

4. ADMINISTRATIVE PROCEDURES AND POLICIES

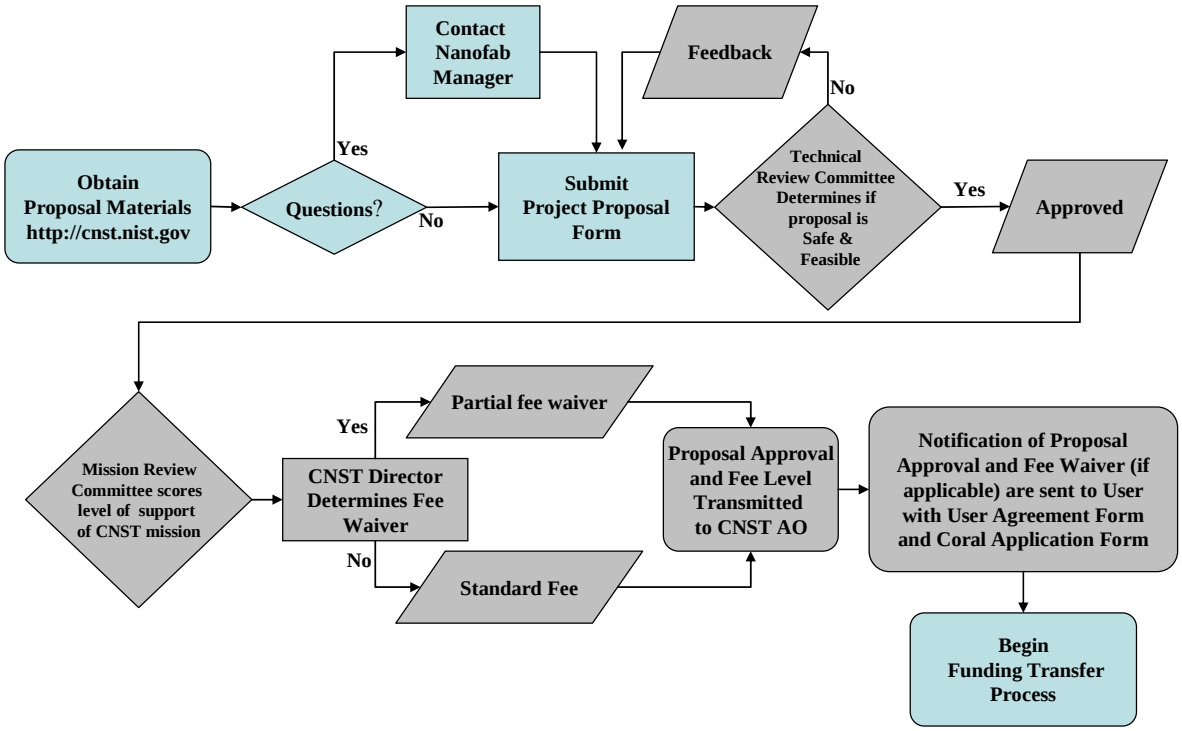
This section describes policies associated with the Nanofab as a whole and the Cleanroom in particular. Only Certified Nanofab Users can independently access the facility. See 3.1 for the process to become a Certified Nanofab User. See section 3.8 regarding visitors. The policies associated with equipment and safety is given in Sections 5 and 6.

4.1 User Access Processes

4.1.1 Proposal Process

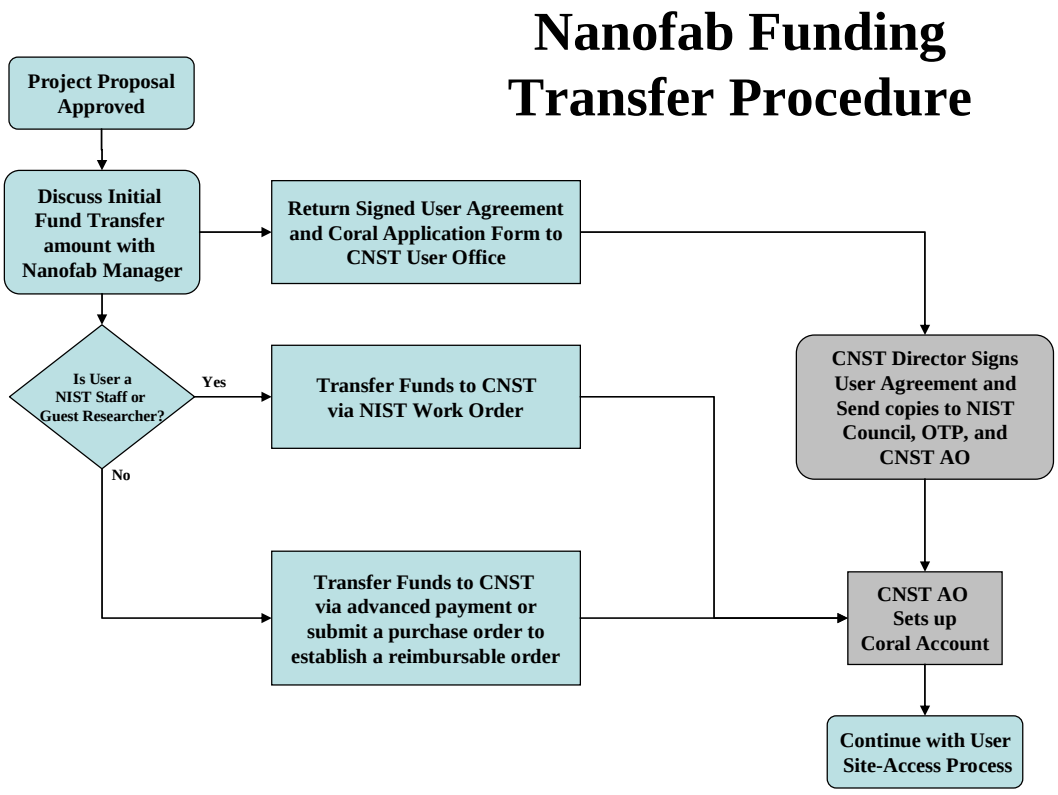
- Discuss the project with the Nanofab Manager.
- Submit a project work proposal form by email to the Nanofab Manager. See Nanofab Website (www.cnst.nist.gov).
- The Technical and Mission Review Committees will review the proposal. If the proposal is not accepted by the Technical review committee, feedback will be provided and the proposer is permitted to resubmit a modified proposal. Proposers will be notified by email of the status of their proposals, and provided a form (Coral Application Form) to open an account with the CNST. The CNST Nanofab Facility uses an electronic scheduling and accounting system called Coral which is described in section 4 below.
- If the proposer is not a NIST Staff member of Guest researcher he will also be provided with the appropriate User Agreement which must be signed and returned with the Coral Application Form

Project Proposal Procedure



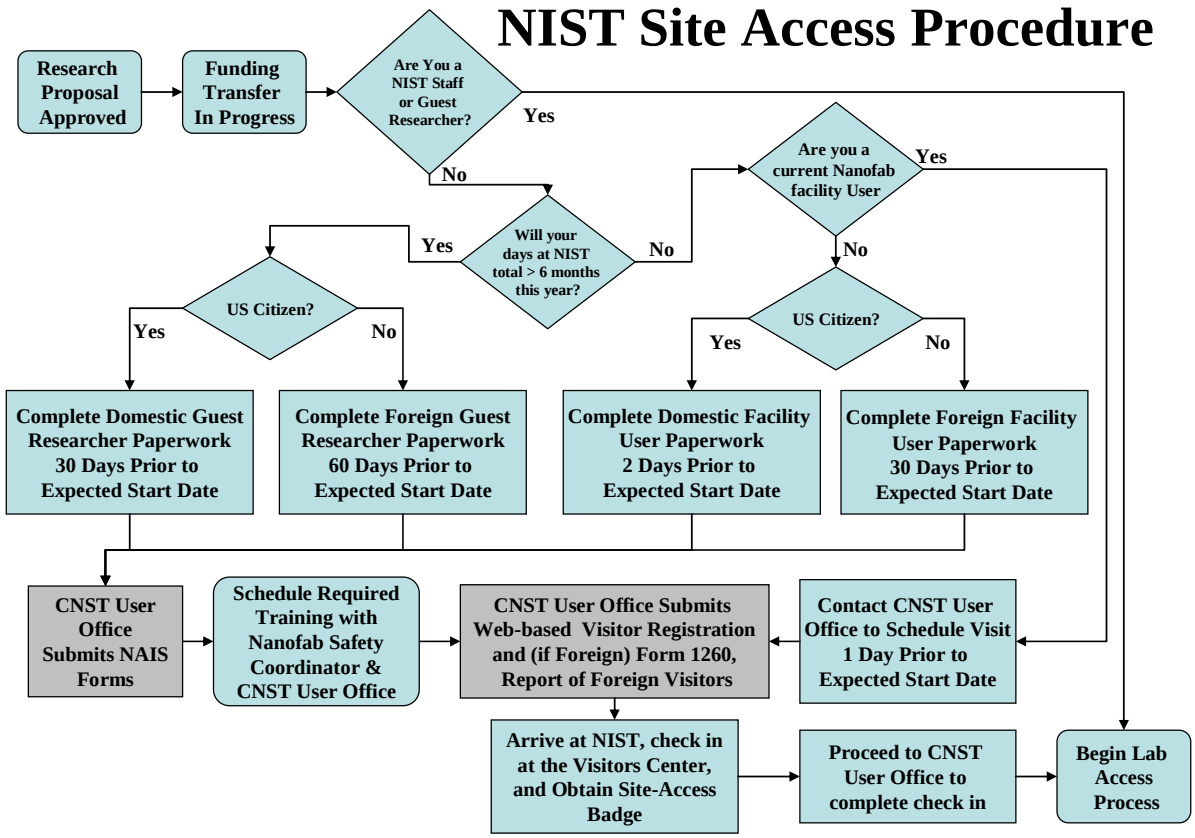
4.1.2 Funding Transfer Process

- Once a Proposal is accepted and the Fee level established, discus the amount of the initial funding transfer with the Nanofab Manager.
- NIST Staff and Current Guest researchers may transfer funds via NIST Work Orders – see your Group Leader and/or AO for further instructions.
- External Users may transfer funds to CNST via advanced payment or submit a purchase order to establish a reimbursable order. Contact the CNST User office for further instructions



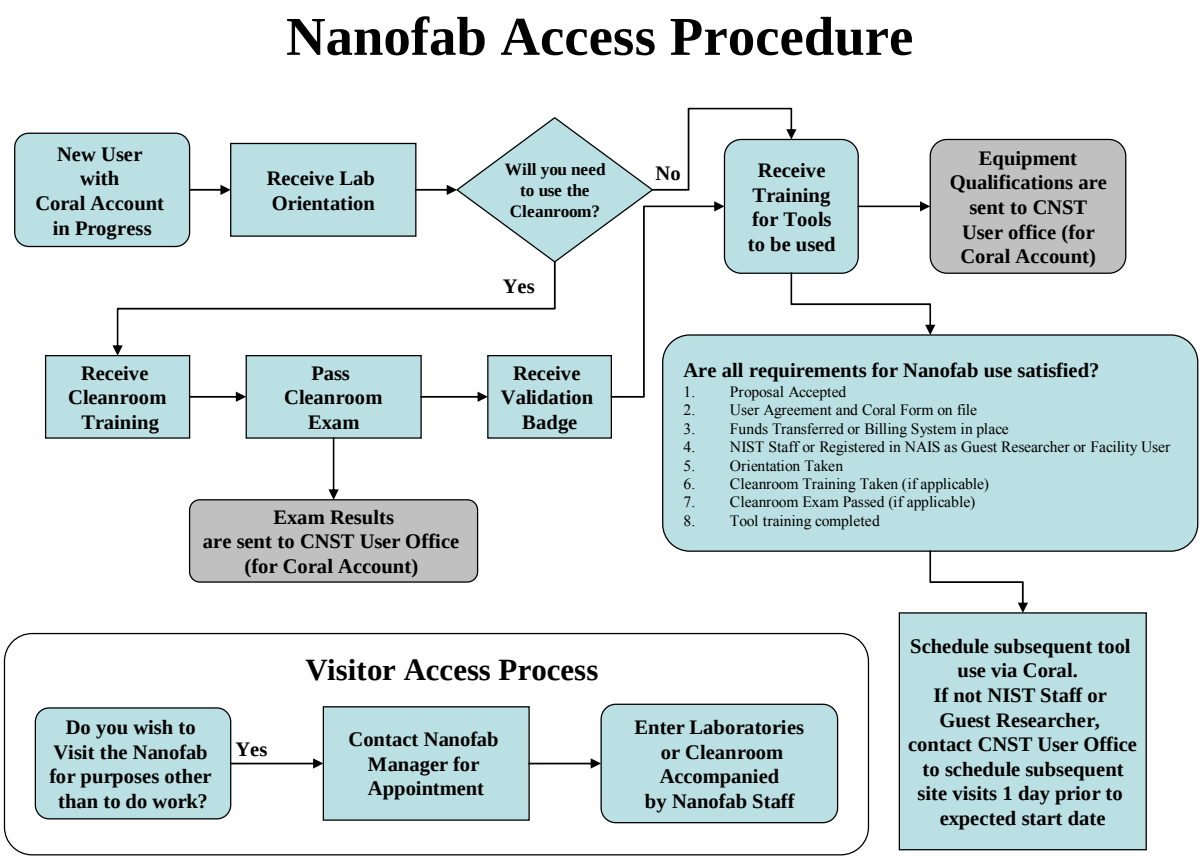
4.1.3 NIST Site Access Process

- Current NIST Staff and Guest researchers already have access to the NIST site and may skip to the Lab Access Process
- Current external Nanofab or Cleanroom users must contact the User Office at least one day in advance of their arrival to arrange for site access
- If a new external user requires access to the Nanofab for more than a total of 6 months in a given year, contact the User office to request the necessary forms to become a Guest Researcher
- If a new external user requires access to the Nanofab for less than a total of 6 months in a given year, contact the User office to request the necessary forms to become a Facility User
- As the application for Guest Researcher of Facility user status approaches completions schedule an appointment for the level of training appropriate to your intended use of the Nanofab.
- When arriving at NIST for training, all external users and persons applying for Guest Researcher Status must check in at the Visitors Center at the NIST Main Gate to obtain a site access badge, then proceed to the CNST User Office for additional check in procedures.



4.1.4 Nanofab Access Process

- Nanofab or cleanroom training should be scheduled with the CNST Nanofab Safety Coordinator
- Cleanroom Users must also take and pass a Cleanroom Exam
- Users then may receive training for the specific tools they intend to use.
- Once all the requirements are satisfied the User can independently use the tools they are trained for
- Subsequent scheduling of tool use is done using the Coral.
- External Users must also schedule subsequent site visits one day in advance with the User Office
- Additional tool training may be scheduled by contacting the Nanofab Manager.



4.2 Usage Fees

All Cleanroom Users are charged usage fees. The usage fees are used to pay for consumables, maintenance, and facility staff. Cleanroom Users are charged an hourly rate for entering the facility and an additional hourly rate for using tools. The hourly rate for entering the facility includes use of wet chemistry, contact lithography and metrology tools (Ellipsometers, Reflectometer, Profilometer, Optical Microscopes, 4-point Probe). The hourly rate for using the Nanofab and tools are available from the Nanofab Manager.

An individual or group of individuals must create an account (see section 3.1.2) that will be charged on a per hour basis. When a Cleanroom User logs into the facility and onto a particular tool through the Coral Software System the user will be asked to enter the account number to charge. The user must log onto the Coral Software System for a particular tool prior to performing any work and log off of the Coral Software System for that particular tool after all work (including shut down and cleans as dictated) is completed on that tool. The Coral Software System will not allow a Certified User to log into the facility or onto a particular tool if there is no balance remaining on the account. The user is responsible for ensuring that a positive balance remains on the account.

Remote Users who ask Nanofab Staff to perform service processing are charged the per hour user fees that the Nanofab Staff incur when using the facility for the remote project plus an additional hourly rate for the Facility Staff time. The Remote User should first discuss plans with the Nanofab Manager. This initial consultation is free of charge. Based on this initial consultation, the Nanofab Manager will generate an estimated cost for the service processing. The Remote User will issue an interdivision work order for the estimated cost. Nanofab Staff will then perform the service processing.

***See Nanofab Website for up-to-date fee schedule at http://cnst.nist.gov*

4.3 Hours of Operation

- Unless otherwise notified, the Nanofab will be open from 7:00 AM to 7:00 PM. Nanofab staff may not be available after hours (Staff Hours: 8:00 to 5:30)
- All tools can be operated outside of Staff Hours except for:
    - LPCVD/PECVD (toxic gas)
    - Wet chemical processing (PR spin and develop and solvent use may be performed out of hours)
    - Metal RIE-Chlorine (toxic gas)
- Out-of-hours policy:
    - The user must contact the Nanofab Management ahead of time to schedule out of hours work.
    - The user may be given specific responsibilities for out of hours work.
        - Get authorization from the Nanofab Cleanroom Management.
        - The Nanofab Cleanroom Management will contact Emergency Response Group at ext. 6190.
        - The after hours user will be required to contact the Emergency Services Group at ext. 6190 when they are done using the lab for the day.

- Should the Nanofab Cleanroom be closed due to laboratory conditions or other problems, the main entry doors to the facility will be locked, a sign will be posted on the main door, and this will also be posted on the Nanofab Forum on the Nanofab website http://nanofab.cnst.nist.gov.

4.4 User Communication

- All issues that pertain to the Nanofab Cleanroom, including closures, emergency situations, equipment failure and repair; will be posted on the forum.
- Please reference the forum frequently enough to ascertain that the lab is safe for entry and the equipment is operational and accessible.
- Signage will also be used.

4.5 Facility Governance and Appeals

- The Nanofab Cleanroom Management will consult with the Nanofab Staff, Safety Committee, Nanofab Safety Coordinator and users prior to pursuing any changes to the policies set forth in this manual.
- The Nanofab Cleanroom Management and Nanofab Staff have immediate authority on all issues and equipment.
- A decision by the Nanofab Cleanroom Management or Nanofab Staff can be appealed to the CNST Director.
- Failure to follow rules or directions of the Nanofab Cleanroom Management or Nanofab Staff can result in suspension of privileges for any time frame to be determined by the CNST Nanofab Manager.

4.6 Visitors

- A visitor is defined as ANY person entering the facility who is not a Certified Cleanroom User or Nanofab Staff.
- Before a visitor enters the facility approval must be obtained from the Nanofab Cleanroom Management.
- Visitors must be escorted at all times by a Certified Nanofab Cleanroom User or Nanofab Staff, and are the sole responsibility of this individual.
- Visitors may observe work, but should never operate or touch any equipment including processing equipment, chemical processing or measurement tools.

4.7 Acknowledgements and Publications

- All output including, but not limited to, publications, presentations, reports, test structures, reference materials, and reference data, involving work performed wholly or partially at the Nanofab, must acknowledge the facility and its sponsors. Please use the following text:

  "Research performed in part at the NIST Center for Nanoscale Science and Technology"

- If the Nanofab Manager or Nanofab Staff contributed in a significant way to the accomplishment of the reported research, then consideration should be given to including the staff as co-author(s). This is most appropriate if the project involved the development of special processing technology by the staff. If you have any questions on who should be included as co-author(s), please do not hesitate to contact the Nanofab Management.

- Copies of publications resulting from your work at the Nanofab should be given to the CNST Nanofab Manager as soon as they are published.

- If at any time during your research at the Nanofab you have developed new processes, please informally communicate these to the Facility Staff, for the benefit of your colleagues.

- If at any time during your research at the Nanofab you have interesting results, please informally communicate these to the Facility Staff, for use in our outreach.

4.8 Intellectual Property

There are a very wide range of interactions possible with CNST. The type of interaction agreed upon for your project will be based on whether your research is proprietary or nonproprietary and the level of collaboration, and will include appropriate provisions governing intellectual property. NIST has a long record of cooperation – formal and informal – with outside organizations. Agreements used to formalize these collaborations include Cooperative Research and Development Agreements, Guest Research Agreements, and Facilities User Agreements. Each type of agreement describes in detail the protection and ownership of intellectual property under that agreement. The agreement used to formalize your collaboration with the CNST will include the intellectual property provisions that are most appropriate for that collaboration.

External users performing proprietary research in which NIST employees do not participate generally *will retain all intellectual property rights*. External users conducting collaborative research with NIST employees *will negotiate appropriate intellectual property* terms in their agreements. Additional Information can be obtained by reviewing the User Agreement for your type of work and by discussing the issue with the Nanofab Manager.

5 CLEANROOM TECHNICAL PROCEDURES AND POLICIES

5.1 User Entry

Entry into the Nanofab Cleanroom is for Certified Cleanroom Users and Nanofab Staff only. Access is controlled and restricted, and can only be obtained if the user has followed the requirements in section 3.1.1. Unless leaving the facility due to an emergency, users shall never enter the equipment corridors or chases without first contacting facility staff.

- Certified Cleanroom Users will enter the Nanofab Cleanroom through Bldg. 215, room D101.
- The User must have a valid NIST ID badge programmed to open the main doors 215/D101.
- Users must log-in and out of the cleanroom computer upon every entry and exit. This allows the facility staff to monitor who is in the cleanroom at all times. The Coral Software System for managing user entry, equipment use and authorization is described in Section 5.

- After successfully logging in, the user can enter the appropriate locker room (men or women). The locker room is for personal belongings. Hair covers, gloves, face masks and booties are required beyond the locker rooms in the Class 1000 gowning room, equipment chases, and corridors.
- The gowning area is where the critical clean area begins, and can be entered through the automatic doors. Cleanroom etiquette and contamination control instructions are given in the next section.
- The following provides the gowning procedure:

    1. The locker rooms are the pre-gowning staging areas.
        - Put on:
            - Hair net
            - Face Mask
            - Shoe covers
            - Latex gloves
            - Safety Glasses
    2. When entering or exiting the gowning area, always use the door to your right.
        - Select gown, hood and boots.
        - Begin to dress from top down.
        - Pull hood over head, and adjust.
        - Step into coverall, and tuck hood into coverall.
        - Put on rubber sole boots and tuck coverall into boots. Adjust.
        - Check yourself in the mirror to ensure there are no gaps in your suit.
        - Swing legs over bench into clean area.
        - Enter the cleanroom through the automatic sliding door.
    3. Safety glasses must be worn at all times.
    4. Do not wear open toe shoes or sandals when working in the facility.
    5. After gowning, do not loiter in the gowning room; do not store your materials (i.e. wafer boxes, cleanroom notebooks, or other supplies) in the gowning room. Enter the cleanroom through the automatic door, and proceed to the work stations. Log into tool computers when tool use is required.

- To exit the work stations and Nanofab, the following procedure shall be followed:

    1. Clean up tool work area.
    2. Run required cleaning recipes if applicable.
    3. Log out of tool computer.
    4. Exit cleanroom through the gowning room automatic door.
    5. If you are done for the week (which runs Thursday through Wednesday), place your garment into the garment hamper and exit the gowning room through the door marked “Exit”. If you are returning to the cleanroom in the same week, hang your garment on the numbered garment rack for use when you return.
    6. Exit to the appropriate locker room.
    7. Discard your pre-gowning supplies, and retrieve your personal belongings.

8. Exit the locker room into the Nanofab Lobby and log out on the Nanofab Computer.
9. Exit the Nanofab.

5.2 Samples, Supplies, and Equipment Entry

- The Nanofab Cleanroom Management must be contacted PRIOR to bringing ANY chemicals, equipment, or questionable items into the facility.
- Personal equipment such as cell phones, camera-phones, digital cameras, PDA's, notebook computers, magazines, books, etc. CANNOT be brought into the cleanroom but can be stored in pockets or in the locker room.
- Samples (tools, wafer containers, supplies, etc.) MUST be cleaned using Propanol-2 and approved cleanroom wipes in the lobby of the cleanroom prior to entering the facility. If you feel that your samples cannot be cleaned prior to facility entrance, contact the Nanofab Management. The proper process for cleaning samples prior to cleanroom entrance is covered in the user orientation.

5.3 Cleanroom Etiquette and Contamination Control

The Nanofab Cleanroom is a Class 100 Cleanroom (Fed. Std.209E). The following rules are based on accepted Class 100 protocols:

- No person, whether certified or not, shall enter the cleanroom unless their physical presence is necessary.
- Personal items that cannot be stored easily in pockets are not allowed.
- Bulky clothes, furs, angora, linty stockings or similar types of clothes are not allowed.
- Clothing minimizing the amount of bare skin is required.
- No cosmetics of any kind are recommended.
- Adequate personal hygiene is required.
- Persons suffering from colds, flu, allergies, and similar illnesses should avoid entering the cleanroom.
- Clean shoes and clothes are required.
- Damaged or dirtied gloves and garments shall be replaced immediately.
- New cleanroom garments shall be used weekly.
- The Nanofab Manager must be contacted prior to bringing any chemicals into the facility.
- Always wear all required gowning as described in 3.3.
- No foam, paper, cardboard or wrapping and packaging material are allowed.
- No paper, except approved cleanroom paper or approved encased paper products, is allowed.
- No tobacco products, spitting, eating, drinking and gum chewing.
- No wooden items are allowed.
- No pencils, felt tips, magic markers or erasers are allowed. Only approved cleanroom pens are allowed (supplied).
- No abrasives such as steel wool, emery cloth or sandpaper are allowed.
- No trash is allowed on the floor and trash shall be immediately put in the appropriate dispenser.

5.4 Equipment Operation

- All equipment in the facility (including chemical processing and inspection tools) has an operations manual available on the CNST website. These manuals describe the procedures and limitations of the equipment. This will includes the types of samples that may be put into the tool.
- Nanofab Cleanroom Staff are responsible for the development and revision of equipment operating procedures.
- ANY use or operation of equipment that falls outside of the procedure described in the operating manual must first be approved by the Nanofab Management.
- The Nanofab Management will base decisions to authorize a change in operating procedure proposed by a user on the recommendations of the user, Safety Committee (if applicable).
- Operating procedures for particular tools can be obtained from the Nanofab website (http://cnst.nist.gov).

5.5 Approved Users and Training

- Users must contact the appropriate Nanofab Cleanroom training staff or management to become trained to operate equipment.
- The training schedules will be posted on the Nanofab Forum.
- Only the Nanofab Staff may train a new user on a particular tool.
- A new user must be formally tested and authorized by a Nanofab Training staff to be approved to independently use a particular tool.
- The Coral Software System will allow only approved users to log-in to the tool.

5.6 Scheduling

- A user must be authorized on that tool to reserve equipment for usage.
- Tools are reserved using the Coral Software System described in 5.4.
- If a user is not using the tool during the reserved time (within 30 minutes), another user may access the tool without reservation.
- Failure to cancel an unneeded reservation is inconsiderate to other users and causes inefficient utilization of resources. It is realized that all projects require a certain process flow between tools so that one problem can throw off your entire schedule. Also, processes can take longer than expected. Thus, while we encourage you to sign up ahead, we also encourage you to be flexible and cooperative with other users in stretching, sharing, and relinquishing time slots.

5.7 Coral Software System - Features

- Reserving (either a multi-day or multi-machine view) of equipment in order to better share scarce resources among the members of the laboratory.
- Software enabling and disabling of equipment to generate records of equipment use for billing purposes.
- Support for maintaining lists of qualified users for each piece of equipment and for checking that each lab member is properly qualified to enable any given piece of equipment.
- Support for reporting and displaying equipment problem and shutdown conditions and for returning that equipment to normal service following repair by maintenance personnel.
- Interface for adding new users to the system and for controlling projects and accounts to which their laboratory use will be allocated.

- Mechanisms to allow staff members to charge users for equipment used on their behalf and to independently re-charge their time to users.

Please see the tutorial at http://cnst.nist.gov to learn how to use Coral

5.8 Equipment Introduction, Installation, Modification, and Repair

- ANY introduction, installation, modification, or repair of equipment must be approved by the Nanofab Cleanroom Management.
- The prioritization of installation, modification, or repair of equipment will be addressed by the Nanofab Cleanroom Management.

5.9 Consumables, Regular Maintenance, and Standard Test Runs

- The Facility Cleanroom Technicians are responsible for replenishing of consumables, regular equipment maintenance, and performing of standard test runs.
- The Facility Cleanroom Technicians have procedures and schedules that describe and track consumables replenishing, equipment maintenance, and standard test runs.
- The Facility Cleanroom Technicians may delegate authority to specific users to replenish consumables, provide for regular equipment maintenance, or perform standard test runs.

6. SAFETY POLICY

- Contact ext. **2222** with emergencies
- A separate Safety Manual describes the details of safety rules including chemical safety, gas safety, and emergency response.
- The Safety Manual can be obtained from facility web site http://nanofab.cnst.nist.gov .
- The staff and management of the Nanofab have implemented all reasonable measures to ensure that the laboratory provides a safe working environment.
- It is the responsibility of all users, visitors, and staff to act in a safe manner at all times while in the facility.
- Safety rules and policies set forth in this manual and the Safety Manual are no substitute for common sense. Operating safely is more important than getting your project, or anything else, done. Ignorance of the rules, lack of common sense, language difficulties, carelessness, and haste are not adequate excuses for unsafe behavior.
- The CNST Nanofab Manager and Nanofab Staff have immediate authority on all safety issues.
- Users violating the safety rules of the facility or endangering the safety of themselves or other users may be denied further access to the facility at the discretion of the management.
- All Certified Cleanroom Users must pass an annual safety and policy exam.
- The Safety Committee will review the development and any revision of the Safety Manual and equipment operating procedures, and all other areas where safety is a concern.
- The Safety Committee will review all safety incidents and will assist in preparing a report on the incident.

7. APPENDICIES

7.1 Names and Contact Information

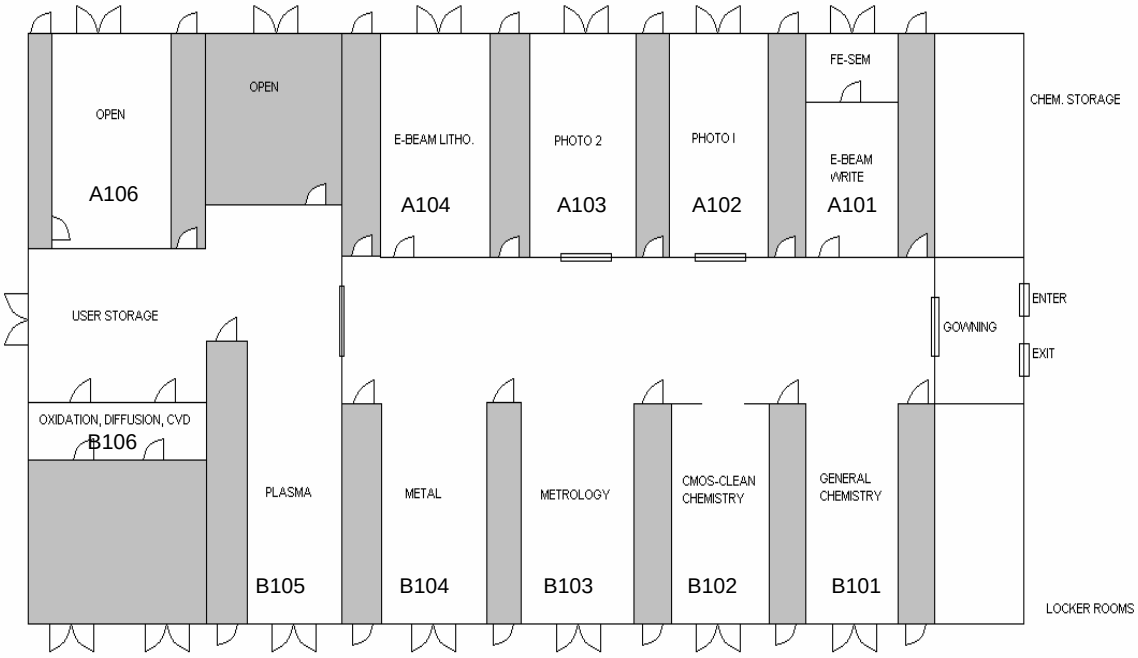
Title	Name	Ext.	E-mail	Office
CNST Director	Robert Celotta	8001	robert.celotta@nist.gov	216/A221
Nanofab Manager	Gerard Henein	5645	gerard.henein@nist.gov	217/A239
Nanofab Assistant Manager	Russ Hajdaj	2699	rhajdaj@nist.gov	217/A247
Facility Technicians	Larry Buck	2242	lbuck@nist.gov	217/A243
Process Engineers	Marc Cangemi	5993	mcangemi@nist.gov	217/A255
	Richard Kasica	2693	richard.kasica@nist.gov	217/A233
	Lei Chen	2908	lei.chen@nist.gov	217/A227
Safety Committee	Russ Hajdaj (Nanofab Safety Coordinator)	2699	rhajdaj@nist.gov	217/A247
	James "Mike" Blackmon (Environmental Safety)	5822	mike.blackmon@nist.gov	301/B122
	Dennis Myers (NIST Occupational Health and Safety) Division)	5823	dennis.myers@nist.gov	301/B122

7.2 Approved Nanofab Chemical List

(For Additional Information on Chemicals, Please see the CNST Nanofab Safety Manual)

2-propanol
Acetic Acid
Acetone
Aluminum Etchant
Ammonium Hydroxide
Ammonium Peroxidisulfate
Buffered Oxide Etch
CR7 Chromium Etchant
CR9 Chromium Etchant
Helium
Hexamethyldisilazane
Hydrochloric Acid
Hydrofluoric Acid
Hydrogen Peroxide
Methanol
Microposit 1165 remover
Microposit 351 Developer
Nitric Acid
Oxygen
PAE Etchant
Phosphoric Acid
Potassium Hydroxide
RS 100 Photoresist Stripper
Silicic Acid
Silicon Etchant
Sulfuric Acid
Tetramethylammonium Hydroxide, 25%
Xenon Difluoride
Ammonia Gas
Dichlorosilane
Forming gas
Hydrogen chloride gas
Hydrogen Gas
Nitrogen Gas
Oxygen Gas
Silane
Ethyl Alcohol
Methyl Alcohol
Oxygen
Xylene

7.3 Nanofab Cleanroom Location Map



7.4 Nanofab Project Proposal Form

To Serve as a guideline the Project Proposal form current at the time of this revision is included on the following page. Before submitting your proposal, please check the CNST website (www.cnst.nist.gov) for an up to date form.

CNST Nanofab Project Proposal Form (v2.0)

Project Title: _____

Proprietary ☐ Yes ☐ No
If Collaborative, Name(s) of CNST Collaborator(s) _____

Principle Investigator (Person responsible for project if not Primary Researcher)

Name:				
Affiliation:				
If NIST: Lab _____	Division _____	Guest Researcher _____	NIST Employee _____	
Nationality (please specify country):				
Category: Student ____	Post Doc ____	Senior Scientist ____	Other ____	
Email:		Telephone:		
Funding Agency:				

Primary Researcher (Person who would visit the Nanofab, if not Project Leader)

Name:				
Affiliation:				
If NIST: Lab _____	Division _____	Guest Researcher _____	NIST Employee _____	
Nationality (please specify country):				
Category: Student ____	Post Doc ____	Senior Scientist ____	Other ____	
Email:		Telephone:		

Co-Researcher 1 (Any others working at the Nanofab)

Name:				
Affiliation:				
If NIST: Lab _____	Division _____	Guest Researcher _____	NIST Employee _____	
Nationality (please specify country):				
Category: Student ____	Post Doc ____	Senior Scientist ____	Other ____	
Email:		Telephone:		

Co-Researcher 2 (Any others working at the Nanofab)

Name:				
Affiliation:				
If NIST: Lab _____	Division _____	Guest Researcher _____	NIST Employee _____	
Nationality (please specify country):				
Category: Student ____	Post Doc ____	Senior Scientist ____	Other ____	
Email:		Telephone:		

(If there are additional co-researchers, attach text containing names and the above information)

Please clearly answer the following:

1. Which aspects of this project require Nanofab capabilities?

2. Describe in some detail the work you intend to conduct in the Nanofab. Specify materials and chemicals you will be using.

3. What equipment will be used to do the work described above, and what is the estimated usage time?

4. Expected start date and duration, and proposed budget.

NOTE: If applying for a fee waiver for non-proprietary research in support of the CNST mission, please answer the following. (Non-proprietary research is not confidential, public access is permitted to the resulting data, and the research in general will be published.)

5. Describe the long-term goal of your research project and its relation to the CNST mission to provide measurement methods, standards and technology to support all phases of nanotechnology development from discovery to production.

6. What is the expected significance of this project and its impact on the field?