

# Cleanroom Safety and Usage Manual



# Purpose of this Training Manual

- Familiarization with the cleanroom
- Familiarization with the working principles in the cleanroom
- Familiarization with the dangers of the cleanroom
- Familiarization with the responses to chemical exposure



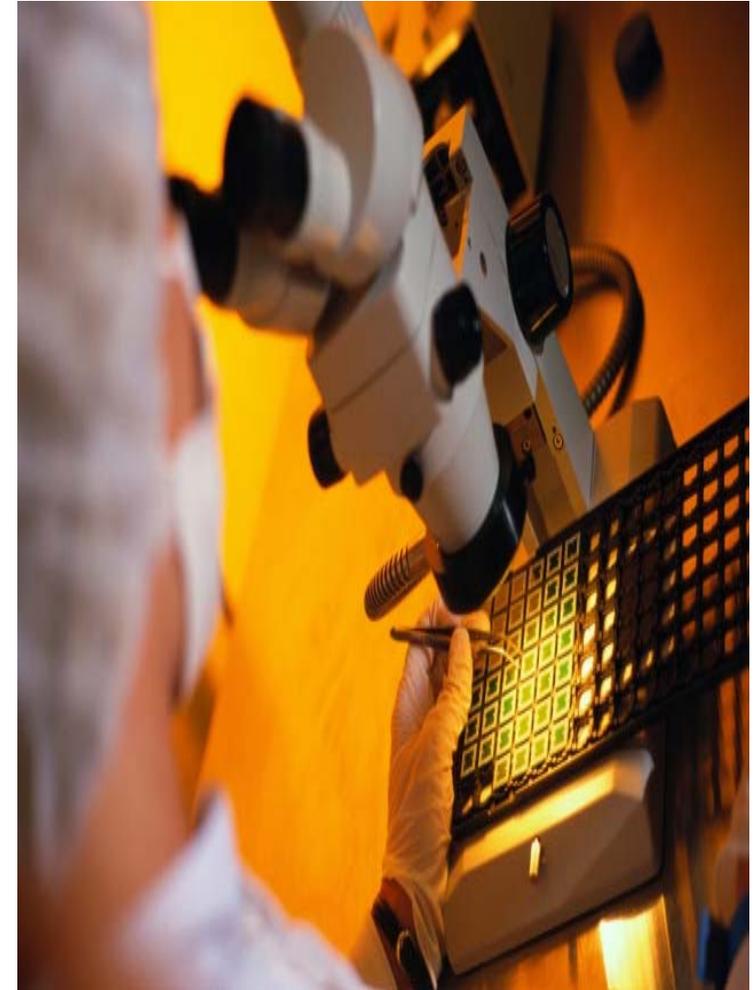
# Essence of this Training Manual

- General work guidelines and procedures were established due to the reality that some cleanroom work when improperly performed can lead to personal injury, the injury of others, and to the damage of the workplace and equipment
- These guidelines and procedures are intended to familiarize cleanroom users with the dangers present in the cleanroom environment
- Though the cleanroom staff has provided these guidelines to help insure safe cleanroom use, the responsibility of ensuring a user's safety lies solely with that user
- Users are responsible for a reasonable amount of basic chemical knowledge, common sense, the intent to maintain one's health and the adherence to these guidelines and procedures without hesitation



# The Purpose of Cleanroom Use

- A cleanroom is an area where the level of cleanliness is maintained at extremely high levels. The exact level is given by class numbers (e.g. Class 100) which relate how many particles of 0.5 microns or greater are contained within one cubic foot of air
- Maintaining a high level of cleanliness allows for the obtaining of desired results from machines, processes and products that are sensitive to environmental conditions (particles, humidity, temperature, contamination, etc.)
- High levels of cleanliness are required for the fabrication of certain products, specifically microchips, whose fabrication can be disrupted by even one grain of dust
- These guidelines will provide for the creation of both a pleasant working environment



# Cleanroom Operating Hours

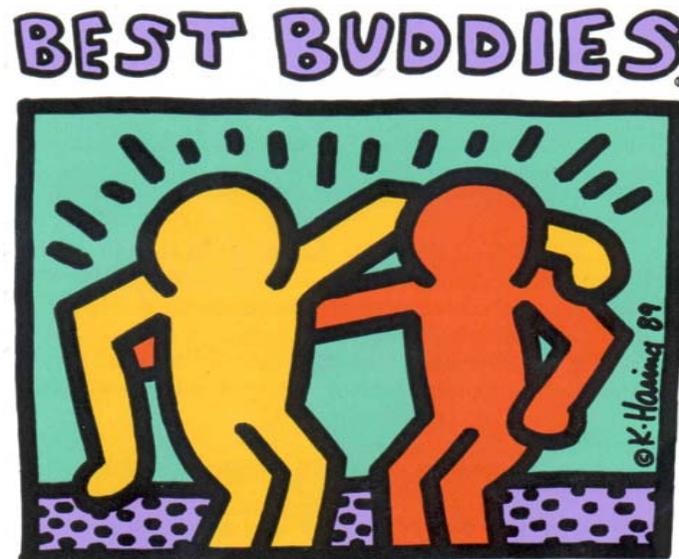
The cleanroom is open to authorized users day and night every day of the week

After 17:00 and on weekends, the presence of another authorized user (i.e. “a buddy”) is required.



# The Buddy System

- Working after hours is allowed only in the presence of another authorized user or 'buddy'
- The purpose of the buddy is to provide assistance in case of emergency or if the user has become incapacitated
- The Buddy System is in place outside of normal work hours (9 AM – 5 PM)



# Cleanroom Class Definition

Particle Size/ft<sup>3</sup>

<b>Class</b>	<b>0.1 <math>\mu\text{m}</math></b>	<b>0.2 <math>\mu\text{m}</math></b>	<b>0.3 <math>\mu\text{m}</math></b>	<b>0.5 <math>\mu\text{m}</math></b>	<b>1 <math>\mu\text{m}</math></b>	<b>5 <math>\mu\text{m}</math></b>
1	35	7	3	1	0	0
10	350	75	30	10	1	0
100	3500	750	300	100	10	1
1000				1000	100	10
10000				10000	1000	100
100000				100000	10000	1000

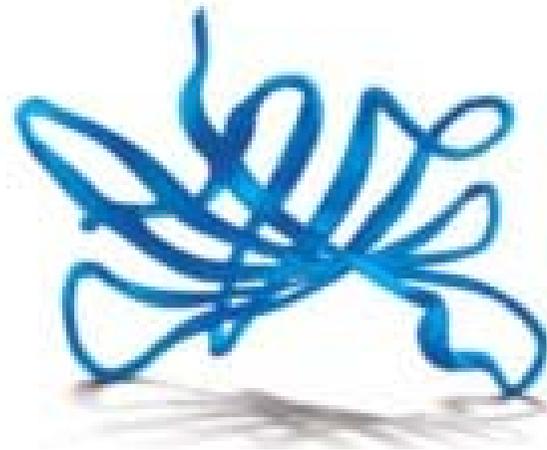
# The Nano Fabrication Cleanroom

## Yellow Room

- Class 1000
- Used for photolithography
- Equipment
  - Fume hood for solvents and acids
  - Karl Süss MJB3 mask aligner
  - Microscope
  - Nano-imprint-lithography (NIL)

## White Room

- Class 10,000
- Equipment
  - VST 680 e-beam evaporator
  - VST Ion beam sputter (IBS)
  - Profilometer
  - Oerlikon RIE plasma etcher
  - Plasma cleaner



# The Engineering Cleanroom

## Yellow Room

- Class 100
- Equipment:
  - Fume hoods for solvents with spinners
  - Karl Suss MA6 mask aligner
  - Heidelberg DWL66 laser writer
  - Oven
  - Olympus MX-40 inspection microscope

## Wet Chemical Processing Room

- Class 100
- Equipment:
  - Silicon wet etch station
  - Wet bench for acids
  - Critical point dryer (CPD)
  - Ultrasonic cleaner
  - Scale



# The Engineering Cleanroom

## White Room 1

- Class 100

- Equipment

  - Plasma Therm 770 DRIE

  - Plasma Therm Versaline DRIE

  - Edwards-306 E-beam evaporator

  - Plasma Preen plasma asher

  - KLA 16P profilometer

  - Jipelec Rapid temperature processing system (RTP)

  - LEXT Olympus confocal microscope

  - AJA Ion milling system



# The Engineering Cleanroom

## White Room II

- Class 100
- Equipment
  - Nextral 860 RIE/HDP etcher
  - Olympus MX-50 inspection microscope
  - Oerlikon 790 PECVD system
  - Woollam M2000 DU spectroscopic ellipsometer

## White Room III

- Class 10000
- Equipment
  - Penta Vacuum RF/DC sputtering system



# Cleanroom Guidelines and Procedures

The following is the breakdown of the cleanroom guidelines and procedures:

- Prior to entering
- Equipment
- Entrance
- Behavior
- Mishaps and problems
- Exiting



# Prior to Entering the Cleanroom

- Confirm that you've registered with the online registration system on the specific equipment or work station
- Wear appropriate clothing
  - Long pants and closed leather or plastic shoes (no sandals or flip flops)
  - Avoid excessive clothing and fabrics that shed excessive fibers like wool
- Makeup and contact lenses are forbidden
- Remember, maintaining a high level of cleanliness is not to protect the user from the cleanroom but rather to protect the cleanroom from the user



# Scheduling

The scheduling system is used to reserve equipment and schedule your work ahead.

The screenshot shows the phpScheduleIt web interface. At the top, there is a navigation bar with links for Dashboard, My Account, Schedule, Application Management, Reports, and Help. The user is signed in as Edith. The main content area is titled "Engineering Clean Room and 301" and shows a date range of 26/01/2014 to 01/02/2014. Below the title, there are buttons for "Reservable", "Unreservable", "Reserved", "My Reservation", "Participant", "Pending", "Past", and "Restricted". The main part of the interface is a grid showing the schedule for Sunday, 26/01/2014, from 12:00 AM to 11:00 PM. The grid lists various pieces of equipment and their status for each hour. The equipment listed includes Vacuum oven 301, Suss MA-6 double side Mask Aligner, Suss RC-8 spin coater, Headway spin coater, Nextral 860 REHDP plasma etcher, PlasmaTherm SLR-770 ICP Deep Reactive Ion Etcher, EDWARDS-306 e-beam evaporator, MRC 8620 RF Sputtering System, Silicon wet etch station (Double book allowed), Wet bench for acid processes (Double book allowed), Photorealist deposition bench (Double book allowed), Photorealist developing/samples cleaning bench (Double book allowed), KLA P16 Stylus Profiler, and Woolam M-2000 DUV Spectroscopic Ellipsometer. The URL at the bottom right is https://schedule.tau.ac.il/nano/Web/schedule.php#.



Go to the website: <http://nano.tau.ac.il/mncf/images/scheduleit.pdf>  
to get more details

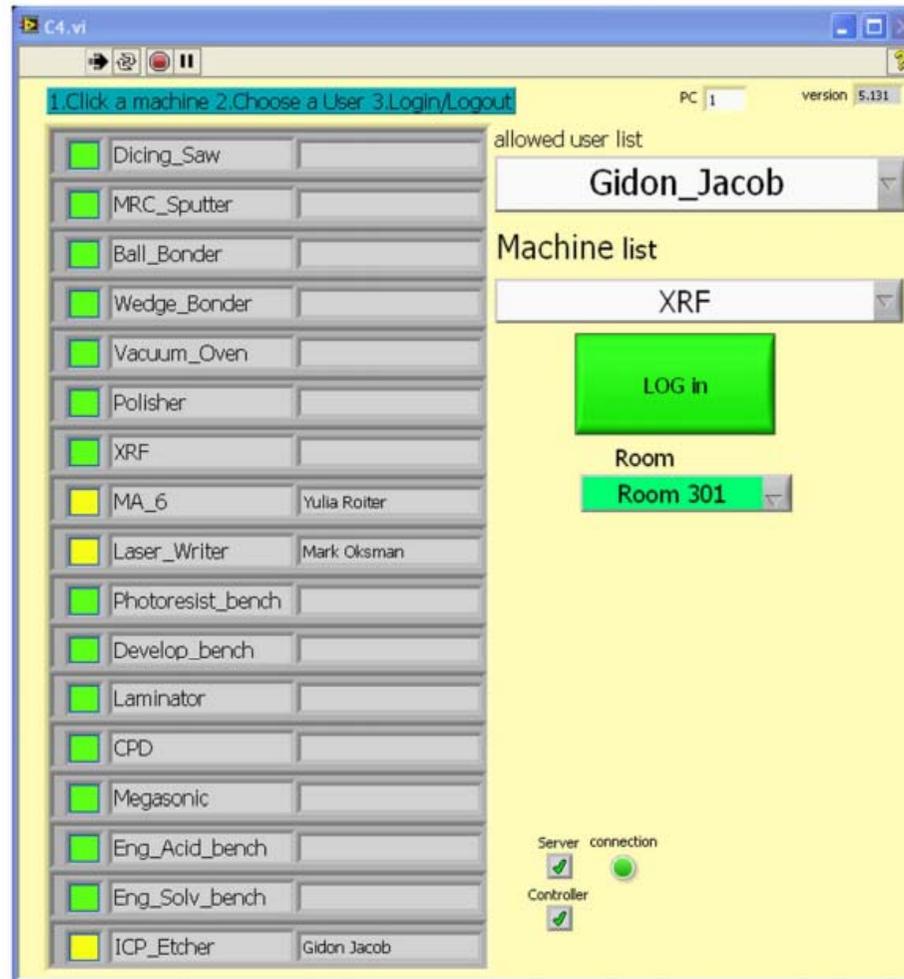
# Cancelling Scheduled Work

- Scheduling more than 4 consecutive hours may need authorization from the cleanroom manager
- It is normally unacceptable to delete scheduled work less than 3 hours prior to the scheduled time
  - Deleting less than 3 hours before will require an explanation to be provided
- As a courtesy, please delete scheduled work no less than 24 hours prior



# Log-in System

The Log-in system is used to access equipment and to charge your supervisor for the work.



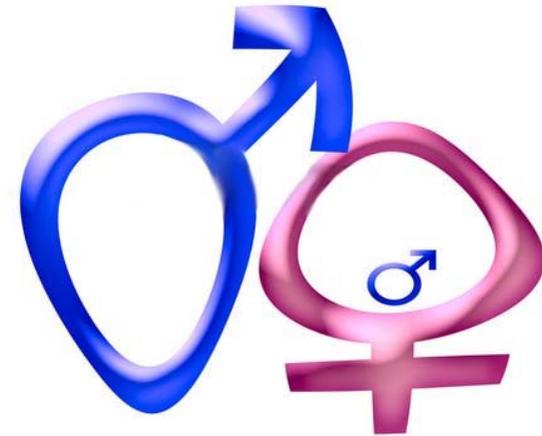
Go to the website: <http://nano.tau.ac.il/mncf/images/SOP/C%20Login%20program%20use%20Feb13.pdf>

to get more details

# Special Circumstances

## Pregnancy

Users who believe they are pregnant must inform the safety supervisors. Pregnancy does not mean completely limit cleanroom work but a discussion on the subject is required in order to obtain guidance. An information page for pregnant women appears on the MNCF website.



## Contact lenses

Contact lenses are strictly forbidden. The presence of contact lenses when chemicals are sprayed in the eyes will worsen the effects. Solvent fumes can diffuse through contact lens and adhere the lens to the cornea. Users who wear contact lenses are responsible for having replacement glasses.



# Cleanroom Equipment

## Permitted items

- Cleanroom notebooks, cleanroom paper, laminated regular paper
- Silicon wafers, tweezers
- Ball point pens
- Items with smooth surfaces that can be cleaned with alcohol
- Flash drives and CDs



## Prohibited items

- Regular paper, Styrofoam
- Powders
- Erasers and pencils
- All items that tend to crumble or shed fibers or particles

Computers and printers are located in the cleanroom for the purpose of viewing and printing recipes. Recipes can be emailed to the user and shared folders can be accessed via the computers.



# General Behavior Guidelines

- No eating and no drinking. Water bottles may be left in the changing room of the Micro and Nano fabrication cleanrooms. There's a water bar inside the cleanrooms for the convenience of users
- Coveralls, shoe covers and head covers must be worn at all times while in the cleanroom
- Reduce the amount of material that is brought in to the cleanroom
- All materials brought in and left in the cleanroom must be labelled with the user's name, telephone number and current date
- Be mindful of keeping your work area as well as the cleanroom in general clean and neat



# Entering the Cleanroom

Consideration must be given to the order of dressing so as to reduce to contamination

- Put on disposable blue shoe coverings and step on sticky mat
- Put on disposable head cover
- Put on coveralls
- Put on non-disposable head cover if using
- Put on non-disposable shoe covers
- Put on gloves
- Put on second pair of gloves (nitrile) if photolithography or chemical work is to be performed
- Put on Safety goggles. Safety glasses must be worn at all times



# Cleanroom Gloves

## Types of gloves

Latex, nitrile, natural rubber

## Purpose of gloves

- To protect the cleanroom environment from contamination
- To protect the user from contact with harmful chemicals



## Use of gloves

- Latex gloves are to be worn at all times while in the cleanroom
- Nitrile gloves are to be worn on top of latex gloves when handling lithographic chemicals (solvents, photoresist, etc)
- Natural rubber gloves must be worn when working with all acids
- When leaving one room to enter another or to leave cleanroom, wash hands and remove and dispose of nitrile gloves (leaving latex gloves on)
- Put on new nitrile gloves before continuing chemical work
- Prior to using, check gloves for holes by inflating glove with air or nitrogen. Fold over the end of gloves to catch any liquid that may drip down. After using, wash and dry rubber gloves and return them to their place

# Cleanroom Mishaps

- For equipment problems such as unexpected equipment behaviour, breakage, etc. it is imperative to 1) place a note on the equipment stating that is non-operational and 2) inform the cleanroom staff of the situation.
- Do not attempt to fix problems by yourself
- The equipment in the cleanroom is very expensive and very sensitive, improper use can cause expensive and time consuming repairs
- These are however university cleanrooms used by professors, students and outside users and it is understood that accidents can and do happen. Unintentional accidents become serious problems if the cleanroom staff is not informed.







# Exiting the Cleanroom

- Clean and organize your work area in the manner that you found it.
- Sign out of the “Log-in” system depending on the machine or work station at which you worked
- Remove your personal equipment, notebooks, utensils, papers, etc. from public areas
- Wash, remove, and dispose of nitrile gloves if wearing them
- Remove cleanroom suits and non-disposable head and shoe covers in gowning room and put them back where they were found. Dispose of gloves and disposable booties and head covers in waste bin



# Fume Hoods



# Dangers in the Fume Hood

- Exposure to chemical\* vapour
- Spraying or splashing of chemicals on skin or clothing or in eyes
- Chemical leaks from bottles or tanks
- Contact with contaminated materials (tools, gloves, etc.)
- Improper mixing of chemicals
- Chemical fires
- Contact with hot plates
- Electrical shock



\*Chemicals = acids, bases, solvents, developer

# Protective Clothing

## Solvents/Bases

- Safety glasses
- Both latex and nitrile gloves (nitrile on top of latex)

## Acids

- Safety glasses
- Latex gloves, rubber gloves, apron and face shield

Before putting on gloves, check for holes by filling with nitrogen or air and holding the base closed.

Rubber gloves should be folded at the bottom to catch dripping liquids.

Hang up the apron such that the side that is intended to make contact with chemicals is facing the closet



# Order for Donning Protective Wear



1) Apron



2) Face shield



3) Gloves

When taking off protective clothing, use the reverse order with which they were put on

In the case that the gloves have been damaged, they should be disposed of

# Basic Rules of Behavior for Fume Hood Work

- Familiarize yourself with the chemicals which you will be working with, the dangers they pose, and the means of dealing with accidental exposure or contact
- It is a requirement to read and understand the MSDS for all the chemicals you will be using before you use them
- It is forbidden to bring chemicals into the cleanroom that have not been authorized by the head of the cleanroom
- New chemicals that have been authorized must have an MSDS
- Every liquid must be treated as a dangerous chemical
- All work with chemicals must be performed within the fume hood
- Do not block the fume hood's air holes including those on the work surface
  - All chemical glassware must be labelled with:
    - 1) material inside
    - 2) name while performing work, phone number should be added if you are leaving the room.



# Basic Rules of Behavior for Fume Hood Work

- When working in the fume hood, it is important to be focused on and occupied with only the task at hand
- Keep chemicals separate! Do not introduce solvents/bases into the acids fume hood or acids into the solvents/bases fume hood
- Remove nitrile/rubber gloves before performing tasks not related to fume hood work (i.e. answering the telephone, microscope work, etc.) or before leaving the chemical room
- Never put your hands, even gloved hands, in chemical baths
- After completing fume hood work, wipe down the tools and work area with clean wipes wet with DI water
- Solvent waste are to be disposed of in the solvent waste bottle, acid waste in the acid waste bottle
- If you worked with dishes, wash them 3 times in the sink and place them in the dish washer.



- Report any incident in order that it can be quickly corrected in order to reduce the chance others being injured

# Chemical Storage

- Specific places in the cleanroom are designated for chemical storage
- The areas for chemical storage are below the fume hoods or in specifically labelled closets
- All chemicals are to be stored in the places specified for them
- Do not store personal/special chemical in the fume hoods without permission from the clean room manager
- All chemicals must be labelled with the contents, date, and user name



# Chemical Identification with PH Paper

- In order to identify the properties of unidentified chemicals, pH paper or, as it is often called, litmus paper can be used
- Dip the paper in the unidentified chemical and wait about one minute until the color changes
- Matching the color to the color on the provided chart will yield the pH level

## pH Levels

0 – very acidic

7 – neutral

14 – very basic



\*pH is a measure of the acidity or alkalinity of a solution. It is based on the concentration of hydronium ions ( $H_3O$ )

# Hotplates

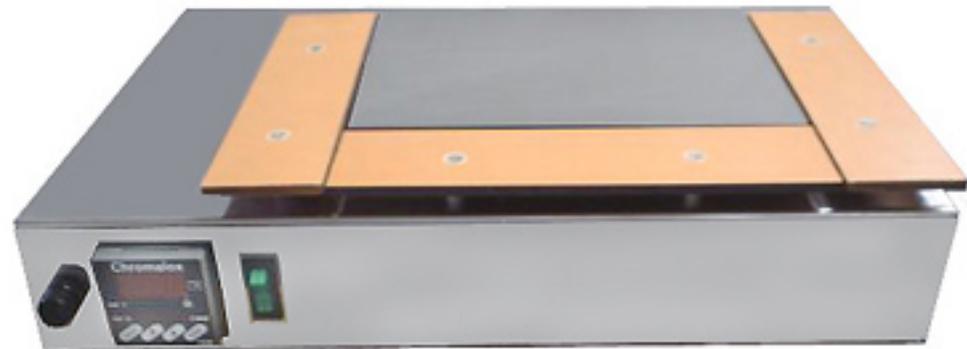
While hotplates may look innocent they can be a source of danger when using them in fume hoods.

The principle danger arises from plastic containers placed on the hotplate catching on fire or melting.

Burns can occur if an operating hotplate is touched .

The rules for working with hotplates:

- You must be present when heating chemicals
- Do not heat solvents with boiling points lower than 130 °F (55 °C)
- Putting acetone on the hot plate is forbidden



# In the Case of Fire...

- In the event of a small fire that does not pose danger to you, try to extinguish the fire at the source
- In the event of a fire, an alarm will sound
- Call security at x8222 or x5555
- There are fire extinguishers in every room and the extinguishers are suitable for use with chemicals
- To extinguish a chemical fire, aim the extinguisher above the burning material in order to stop the supply of air
- If the situation is one that endangers your health or life, leave the area immediately through the emergency doors without taken the clean room suit off



# Chemical Exposure – Eyes

- Flush with water using eyewash, assistance from another cleanroom user is advised. In the nano clean room there's a bottle of eyewash fluid on the shelf to the right hand side of the hood.
- Time is critical when flushing chemicals from eyes, wash for at least 15 minutes
- In order to not damage your eyes, eyewash water pressure is low. For the same reason, the water is cold
- Seek medical care as soon as possible!
- Keep others informed of your situation



# Chemical Exposure – Skin

- In the case of chemical exposure or suspected chemical exposure to skin, wash the area immediately for at least 15 minutes in the nearest faucet or eyewash
- For larger exposures use shower. The shower at the Nanocenter is located at the entrance to the clean room corridor.
- If your clothing has been exposed, first take off clothes then use shower
- Inform those around you or the cleanroom staff of your situation
- Seek medical care as soon as possible!
- It is important to remember that cleanroom suits, and head and shoe covers will not protect you from chemical spills





# HF Exposure



- HF exposure may not cause any sensations or feelings yet can be fatal
- Visible signs of HF exposure may not appear until the next day
- HF will absorb through the skin and through the muscle until it reaches bone where it will begin reacting with the calcium in the bone
- Higher concentrations will cause more intense reactions that occur more quickly
- If not treated immediately, HF exposures may require amputation
- In the case of HF exposure:
  - 1) Inform those around you of the exposure, inform the CR staff
  - 2) Wash the exposed area with water for 15 minutes
  - 3) Open HF Treatment Kit
  - 4) Continuously apply generous amount of calcium gluconate cream to exposed area
  - 5) Seek for medical help, have a friend inform the hospital of the situation. Take the laminated MSDS with you.
  - 6) At the hospital, the doctor may inject calcium based solution into the affected area



# Chemical Accidents and Response

- Every chemical accident must be reported to cleanroom heads at telephones
- At Nano 8432,5713                      Maintenance staff 9474, 8561
- At Engineering 5303,6938              Maintenance staff 8869
- In the case of liquid spills, every liquid must be considered to be dangerous
- Spills of water, acetone, or IPA can be cleaned with cleanwipes
- In the case of large spills, use chemical sleeves to surround the spill and slowly contract until all of the liquid has been absorbed
- Spills in hard to reach places or HCl spills should be absorbed with granules
- After absorbing all liquid with cleanwipes, sleeves or granules all materials should be placed in two plastic bags located under waste baskets



# Treating Electric Shock

## Dos

- Switch off the main switch
- Break the contact between electrical source and patient using dry non-conductive object like wooden stick (designated hooks are located in both clean rooms)
- Call for help
- If breathing and heartbeat has stopped begin C.P.R



## Don'ts

- Touch the patient directly
- Alerting from within side a high voltage area

# List of Common Chemicals – Acids



<b>Chemical</b>	<b>Danger</b>
HF	May show no signs, reacts with calcium in bones, can be fatal
HCl	Causes severe skin burns
BOE 6:1	Contains HF, see dangers above
Sulfuric Acid	Causes severe skin burns
Ti etch	Flammable
Au etch	Burns skin
Nanostrip	Burns skin, can be explosive
Piranha	Burns skin, can be explosive
H <sub>2</sub> O <sub>2</sub>	High concentrations can ignite and explode and are corrosive

# List of Common Chemicals – Solvents

<b>Chemical</b>	<b>Danger</b>
NMP	Flammable
Sodium Hydroxide	Causes burns, blindness
IPA	Flammable
Acetone	Flammable
Developer MF-319	Poisonous
Developer MF-726	Poisonous
PM – Acetate	Flammable, poisonous
Microposit Remover 1165	Poisonous



# Chemical Waste

## Acids

All acid waste should be collected in specifically labelled containers.

Containers are labelled as one of three types:

- HF
- Other acid
- Solvents

Under certain circumstances, with an acid neutralizer installed, some acids may be safely poured down the drain along with significant amounts of water. Ask the cleanroom staff for advice regarding which acids.



If you plan to work with Piranha please make sure you read the SOP.

[http://nano.tau.ac.il/mncf/images/SOP/Piranha\\_SOP\\_MNCF.pdf](http://nano.tau.ac.il/mncf/images/SOP/Piranha_SOP_MNCF.pdf)

## Solvents

All solvents should be collected in containers labelled 'solvents'  
Under no circumstances should solvents be poured down the drain.

If a waste bottle is full you may start a new one by choosing the compatible empty bottle of the same group.



# The NFPA Diamond

- The NFPA diamond is designed to give general hazard information for chemicals.

## Red: Fire Hazard

- 0 – Will not burn
- 1 – Must be preheated for ignition; flashpoint above 200°F (93°C)
- 2 – Must be moderately heated for ignition, flashpoint above 100°F (38°C)
- 3 – Ignition may occur under most ambient conditions, flashpoint below 100°F (38°C)
- 4 – Extremely flammable and will readily disperse through air under standard conditions, flashpoint below 73°F (23°C).

## Blue: Health Hazard

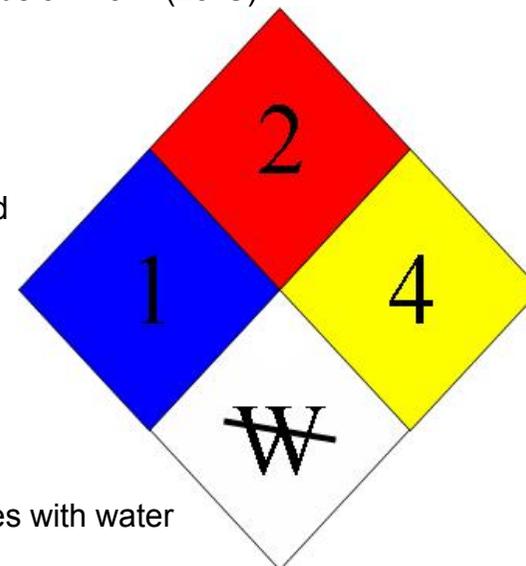
- 0 – Hazard no greater than ordinary material
- 1 – May cause irritation; minimal residual injury
- 2 – Intense or prolonged exposure may cause incapacitation; residual injury may occur if not treated
- 3 – Exposure could cause serious injury even if treated
- 4 – Exposure may cause death

## Yellow: Reactivity Hazard

- 0 – Stable
- 1 – May become unstable at elevated temperatures and pressures, may be mildly water reactive
- 2 – Unstable; may undergo violent decomposition, but will not detonate. May form explosive mixtures with water
- 3 – Detonates with strong ignition source
- 4 – Readily detonates

## White: Special Hazard

- OX** Strong Oxidizer
- W** water reactive



# MSDS

The Material Safety Data Sheet (MSDS) is a form that provides information on chemicals regarding

- Physical properties
- Toxicity and health effects
- Safety, handling and disposal procedures
- Response to exposure and first aid
- Reactivity
- Protective equipment and clothing requirements
- Spill response



The data sheet format is exact though it may differ from form to form. Data sheets often begin with specific materials characteristics (color, smell, boiling point, etc.), toxicity, safety precautions, and first aid response. Data sheets often also include lengthy and specific material descriptions that should be read prior to chemical use.



# MSDS

- The MSDS of all materials in the cleanrooms and room 301 are collected in notebooks and appear on the MNCf website:

<http://nano.tau.ac.il/mncf/index.php/msds>

- Locations of MSDS notebooks:

Microfabrication cleanroom – red binder can in the first change room under the coat rack

Room 301 – black binder by the entrance under the coat rack

Nanofabrication cleanroom – Entrance cabinet

- Material data sheets should be read and understood prior to working with chemicals.



# MSDS Terminology

## Pyrophoric

Flammable, will combust spontaneously with contact with air without spark or ignition. An example is silane

## Flash Point

The lowest temperature at which a material will form a combustible mixture with air, normally by first producing vapor

## Exothermic Reaction

In chemistry, this is a reaction that produces excess heat. In contrast, endothermic reactions absorb heat



# MSDS Terminology

## Acute Exposure

Specifically, a single exposure to a substance. With regards to toxicity, acute exposure often means a single exposure incident that may result in physical harm or death

## Chronic Exposure

Specifically, long term exposure to a substance. With regards to toxicity, chronic exposure occurs over months or years and build up over time. The effects may be irreversible and may include genetic mutation

## Local Exposure

Exposure to a substance that is localized to small area of the body or skin

## Systemic Exposure

Exposure to a substance that occurs over the whole body or bodily systems. Mostly occurs by adsorption, swallowing, or breathing.



# MSDS Terminology

## Acute Effects

Specifically, effects that are seen hours or days after exposure to a substance.

## Chronic Effects

Specifically, long term effects that occur after exposure to a substance

## Local Effects

Effects that occur over a small area of the body, typically the area of contact with a substance

## Systemic Effects

Effects that occur over the whole body, or areas of the body other than those that contacted the substance

## Allergies and Hypersensitivity

Allergic reactions, or sensitivities, are unexpected and abnormal immunological responses of the body following exposure to certain substance. In general, the response is not associated with disease. Allergic reactions are considered positive immunological responses of a healthy body. Allergic reactions are considered negative when they are 'faults' in the immune system



# MSDS Terminology

IDLH – Immediately Dangerous to Life and Health

Often expressed in parts per million (PPM), IDLH is the amount of substance that need be present where any exposure is considered life threatening or resulting in permanent injury

STEL – Short Term Exposure Limit

The amount of a substance that need be present where exposure for less than 15 minutes or less will not cause physical injury

PEL – Permissible Exposure Level

The legally allowable amount of exposure to a substance. Normally given in PPM and often time weighted where exposure to higher level are acceptable as long as the average concentration over 8 hours remains lower

LD50 or LD<sub>50</sub> - Median Lethal Dose

The abbreviation of 'Lethal Dose, 50%.' Refers to the amount of a substance required to kill 50% of a tested population (humans). It is generally used as an indicator of a substance's acute toxicity. Often given as grams or mg or µg of substance per kg of body mass of an individual. This is not the lethal dose for all subjects, some individuals may be killed by much less



# MSDS Terminology

## Carcinogen

Any substance that promotes or causes cancer

## Mutagen

Any substance that changes in an organisms genetic information (typically DNA). Many mutations cause cancer, thus many mutagens are also carcinogens.

## Teratogen

Any substance that can cause embryonic deformities or as are commonly known as birth defects

