# Introduction to NNFC protocols

National Nanofabrication Centre

Indian Institute of Science

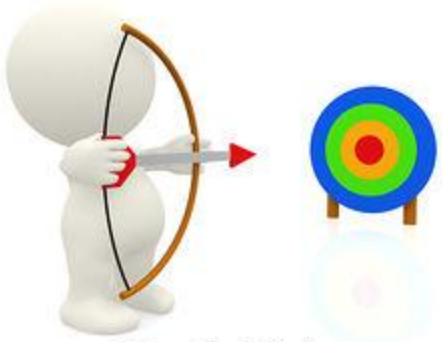
Bangalore

# Outline

- **Aim**
- **What is cleanroom?**
- **Why cleanroom training?**
- **Contamination**
- **Cleanroom protocols**
- **Do’s and don't's**

# Aim

**Appreciation of cleanroom practice**




**You keep it clean**

**and**

**Do reproducible research SAFELY**

# What is a clean room?

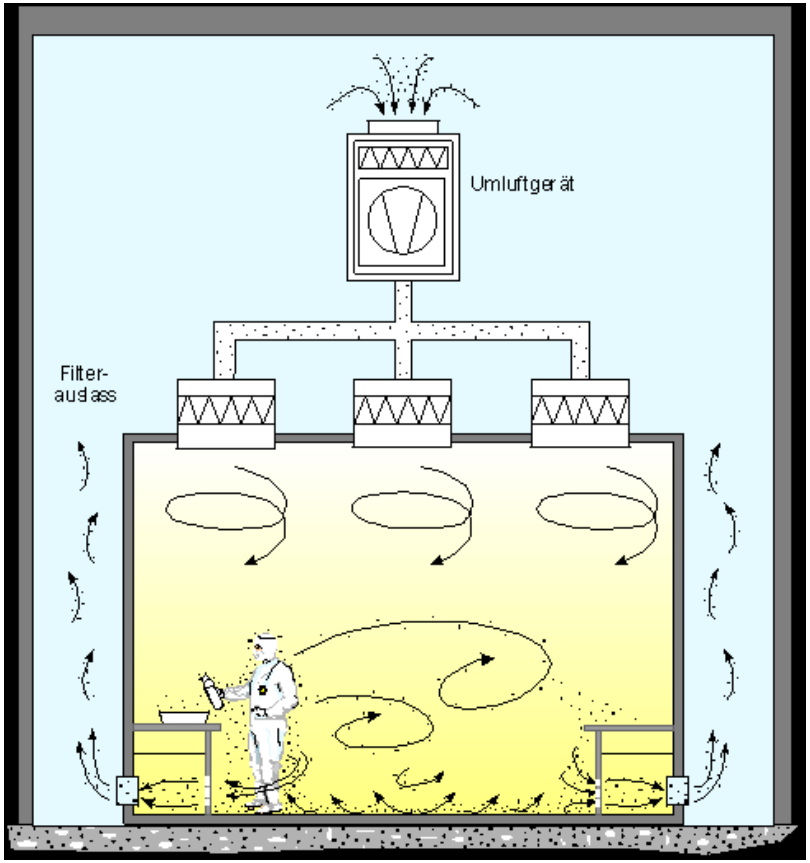
- **A clean room has a *controlled* environment**
  - **Low contamination (like dust, airborne microbes, chemical vapours etc)**
  - **specified by the number-of-particles/$ft^3$ at a specified particle size**
- **Eg: Room with < 100 particles/$ft^3$ equal to or larger than 0.5 micron is a class 100 clean room.**

# Classification of cleanrooms

| Class | maximum particles/ft³ | | | | | ISO equivalent |
|---|---|---|---|---|---|---|
| | ≥0.1 µm | ≥0.2 µm | ≥0.3 µm | ≥0.5 µm | ≥5 µm | |
| 1 | 35 | 7 | 3 | 1 | | ISO 3 |
| 10 | 350 | 75 | 30 | 10 | | ISO 4 |
| 100 | | 750 | 300 | 100 | | ISO 5 |
| **1,000** | | | | **1,000** | 7 | ISO 6 |
| 10,000 | | | | 10,000 | 70 | ISO 7 |
| 100,000 | | | | 100,000 | 700 | ISO 8 |

# Principles of the Clean Environment

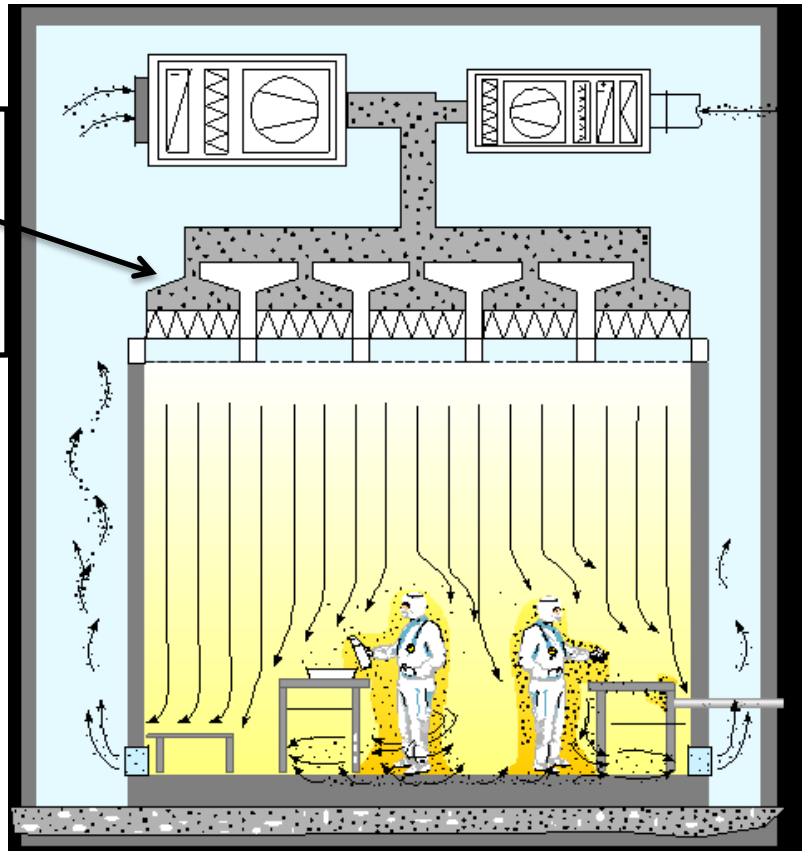
## Non-unidirectional




"dilution effect“- non-parallel /non-uniform flow streams and velocities. clean air entering the room and diluting the contaminated air.

HEPA- high-efficiency particulate air filter

## Unidirectional - Laminar



"piston effect“- where incoming clean air "pushes" contaminated air from the room

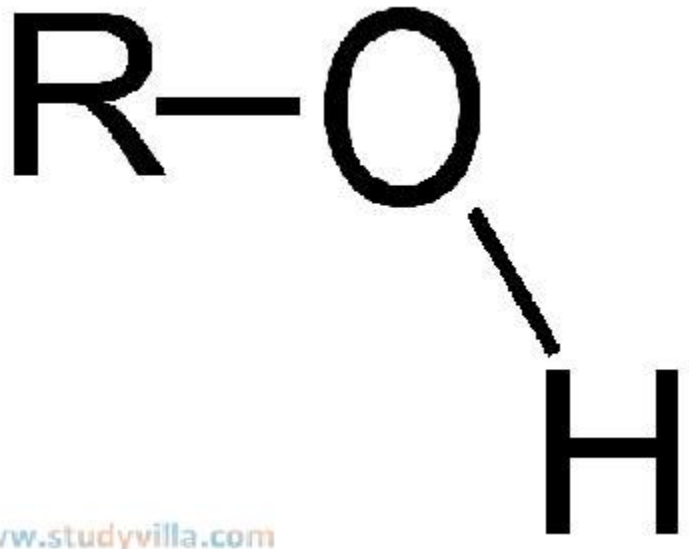
# Why the training?

- **The Clean room environment is carefully maintained at particular standards and has equipments which are delicate and precisely calibrated**
- **The chemicals and gases used in the facility may be extremely hazardous**
- **Misuse may lead not only to destruction/malfunctioning of the device, but could also pose danger to personnel/instrument**

# Contamination types

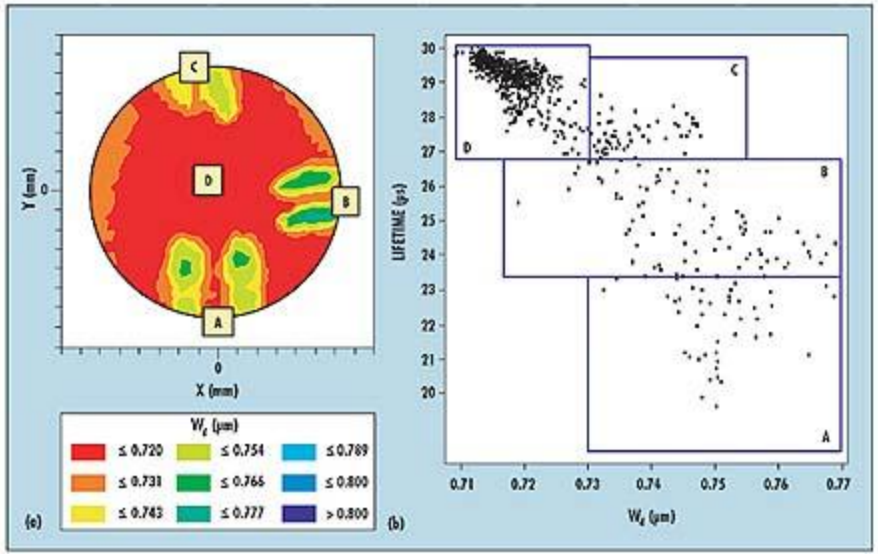
# Molecular contaminant sources

- **Out gassing**
- **Oil vapours**
- **Alcohols**
- **Paints, glues, & epoxies**
- **Aromatics; If you can smell it, suspect it as a contaminant**



# Sources of surface contamination

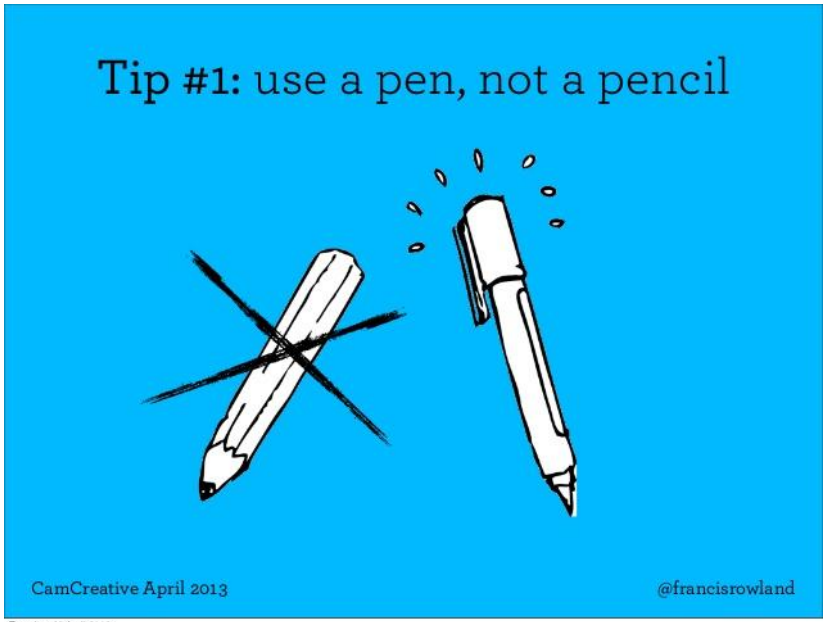
- **Finger prints - Oil & grease**
- **Skin oil**
- **Hand cream**
- **Face cream, Wax**
- **Polish**




http://micromagazine.fabtech.org/archive/06/03/sokolov.html

# Sources of particulates

- **People (skin, scales, hair, clothing lint, etc.)**
- **Particle shedding materials (cardboard boxes, paper)**
- **Abrading actions (drilling, sawing, sanding, etc.)**
- **Bare wood products**



# Effect of different cosmetics (http://www.lricks.com/crpage1.htm)

| Table I. Chemical Analysis of Skin Flakes Vs Cosmetic Flakes | | | |
|---|---|---|---|
| **Electrolytes in Skin Tissue** | | **Dominant Elements in Cosmetics** | |
| **Cations** (Concentration in the body) | **First Ionization Potential** | **Element** | **First Ionization Potential** |
| Na+ (3179 ppm) | -2.710 eV | Ti | 6.82 eV |
| K+ (152 ppm) | -2.931 eV | Tc | 7.28 eV |
| Ca++ (14 ppm) | -2.868 eV | P | 10.49 eV |
| | | Si | 8.15 eV |
| | | Al | 5.99 eV |
| **Anions** | | Fe | 7.87 eV |
| C1- (2556 ppm) | +1.358 eV | Mg | 7.65 eV |
| HC03- (1664 ppm) | +1.080 eV | Cr | 6.77 eV |

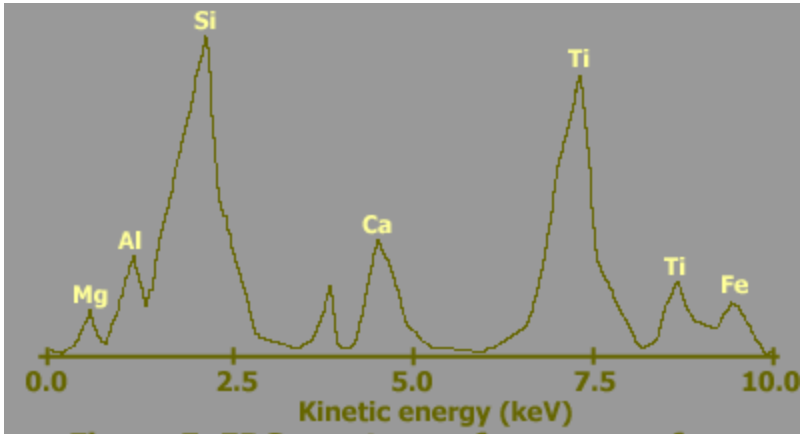


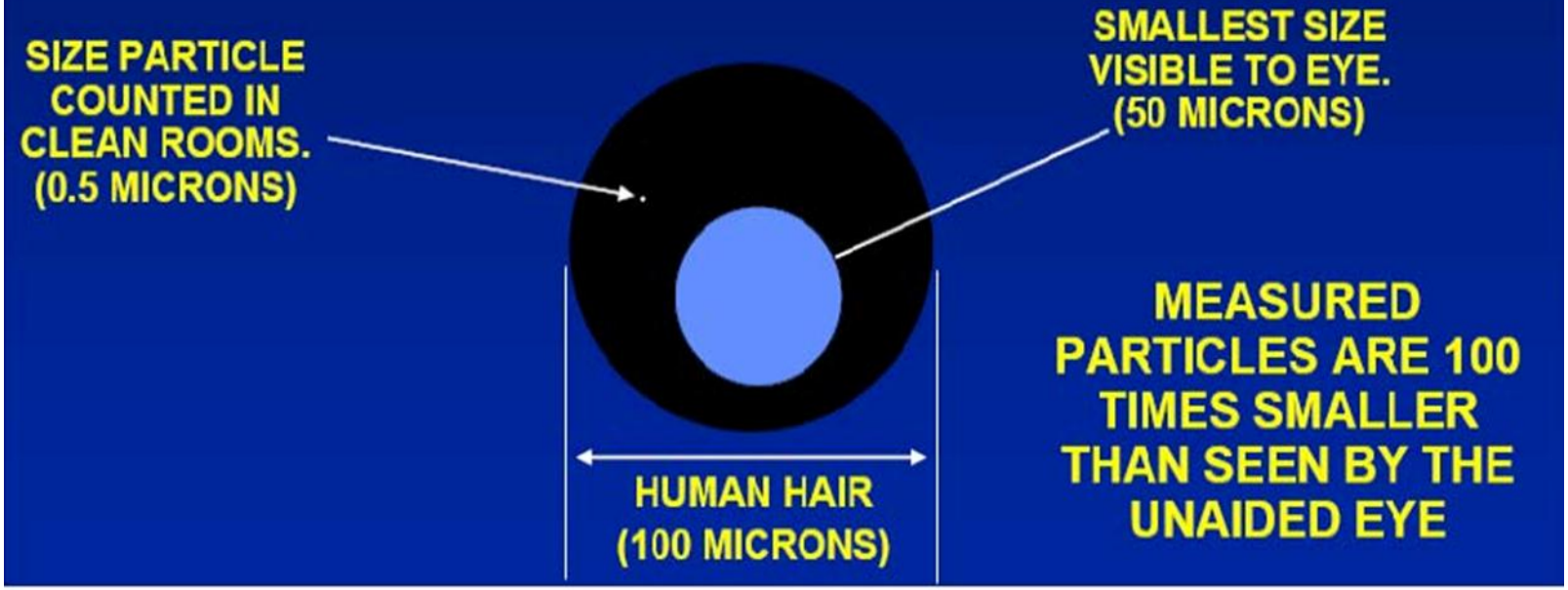
Figure 5. EDS spectrum of a common face powder (residue)

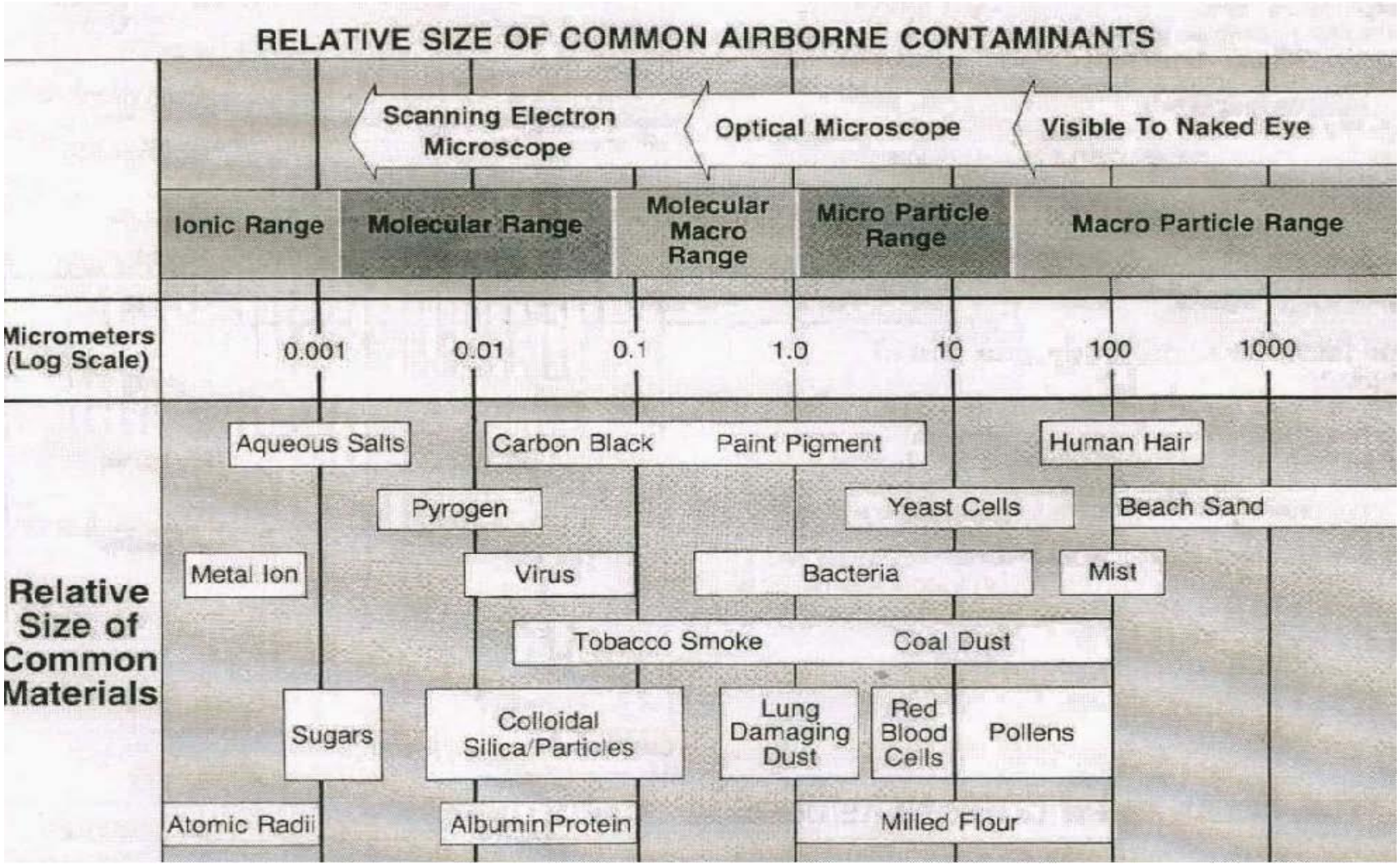
**Change in Electrical parameters of a wafer was contaminated with a common talc** →

| | |
|---|---|
| -channel threshold voltage | Δ +0.10 VDC |
| p-channel breakdown voltage | Δ -4.72 VDC |
| source-drain resistance(N+) | Δ+8.59 Ω/sq. |
| p-channel threshold voltage | no change |
| metal 1 to poly+ resistance | > 800 Ω |

# RELATIVE PARTICLE SIZES

MOST PARTICLES ARE TOO SMALL TO BE SEEN WITHOUT AID. THEIR SMALL SIZE RESULTS IN ELECTROSTATIC BONDING TO SURFACES

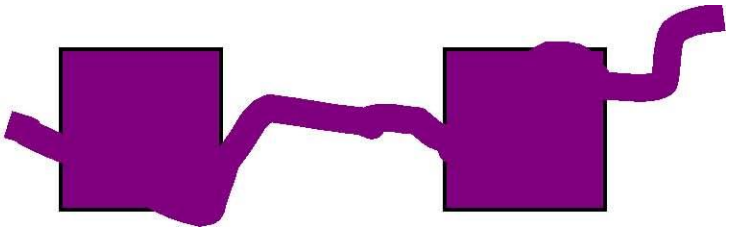



RELATIVE SIZE OF COMMON AIRBORNE CONTAMINANTS
Scanning Electron Microscope
Optical Microscope
Visible To Naked Eye
Ionic Range
Molecular Range
Molecular Macro Range
Micro Particle Range
Macro Particle Range
Micrometers (Log Scale)
0.001
0.01
0.1
1.0
10
100
1000
Relative Size of Common Materials
Aqueous Salts
Carbon Black
Paint Pigment
Human Hair
Pyrogen
Yeast Cells
Beach Sand
Metal Ion
Virus
Bacteria
Mist
Tobacco Smoke
Coal Dust
Sugars
Colloidal Silica/Particles
Lung Damaging Dust
Red Blood Cells
Pollens
Atomic Radii
Albumin Protein
Milled Flour

Effect of Contamination:

# Presence of a fibre on the mask during lithography

**What you wanted**



**What you got**

*High contamination source ?*

# Contamination Sources

- **People ~75%**
- **Ventilation ~15%**
- **Room Structure ~5%**
- **Equipment ~5%**

# You are the Primary Contaminant!

100 000

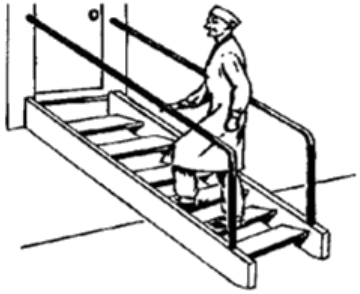
500 000

1 000 000

2 500 000

5 000 000 - 10 000 000

[ particles/min >0,3µm]



10 000 000

15 000 000- 30 000 000

# SIZE DISTRIBUTION of PARTICLES from SNEEZES or COUGHS

| DIAMETER | SNEEZE | COUGH |
|---|---|---|
| • <1-1 uM | 800,000 | 66,000 |
| • 1-2 uM | 686,000 | 21,000 |
| • 2-4 uM | 280,000 | 1,600 |
| • 4-8 uM | 134,000 | 1,290 |
| • 8-16 uM | 36,000 | 490 |
| • +22 uM | 4,500 | 85 |
| TOTAL | 1,940,000 | 90,765 |

# Personal Protection equipments

- **Use appropriate personal protection equipments (PPE)**
  - **In the wet bench area**
  - **In the main clean room**


**Detailed Gowning /ungowning Procedure video at NNFC website**

# Just after you enter

- **A class 100 area at the entry point**
- **Make sure the door is open from one side**
- **Make sure you spend a minute there**

# Q: Why is the procedure important?

- **Want the dust you generates to fall INSIDE your suit, NOT OUTSIDE.**
  - **So, the boot covers go OVER the suit, NOT UNDER**

- **If you put on your gloves and then use your hands to gather your hair and put it under a cap, the gloves will have oil and skin flecks on the outsides from your hair.**

# Cleanroom Entry Protocols

- **All authorized users MUST use the biometric access prior to entering.**
- **NO TAILGATING.**
  - **Do not allow another users to enter the cleanroom along with you.**
  - **After the door closes, he or she will have to log in separately through his or her biometric access.**
- **Do NOT take guests along with you.**
  - **Permission is required from NNfC office, even if you need to take a visitor around the corridor.**
  - **All visitor details should be logged in the register placed @NNfC Office.**
- **Violation of the above protocols WILL result in permanent suspension of access to the facility.**

# Cleanroom protocols

- **Please wash your hands and face with lots of water before coming into the clean room**
- **If you ate something just before coming into the cleanroom, drink water and rinse your mouth thoroughly**
- **If you smoke, drink water before coming into the cleanroom**
- ***Do not come in with torn and/or dirty socks***

# Cleanroom entry

**Allowed:**

- **Clean, dry clothes are mandatory.**
- **Half/full sleeved shirts (shirts should cover from arms to waist) and full length pants (covering from waist to ankles) are required.**
- **Churidhars and Salwars are allowed.**
- **Clean socks or stockings are mandatory.**

***Note:*** **Please make sure that long or medium length hair is tied back. Contact lenses are strictly prohibited**

# During Pregnancy

- **Please avoid using the cleanroom during pregnancy and breast feeding**
  - **Be a dependent user for the duration**
- **In case cleanroom entry is necessary, please discuss the risks with the safety committee members after submitting a copy of your process details**
- **Retraining is necessary once your comeback**

# Cleanroom Entry: Not allowed

- **Clothes which are dusty, dirty or wet**
- **Sleeveless clothes, shorts or short-pants**
- **Tank tops, halter tops and sphagetti strap tops, and gowns**
- **Clothes which shred fiber like fur, mohair etc**
- **Deodrants, perfumes and cosmetics including hand cream**
- **Heavy jewellery and decorative accessories including flowers**
- **People suffering from cough, cold or respiratory diseases**
- **People with pacemakers, food and Beverages**

# Cleanroom Don’t’s

- Do not bring any tools/ equipment from outside into the cleanroom and do not take anything away from the cleanroom.
- No using cellphones during processes even if connected to hands-free, CELL PHONES COMPLETELY BANNED FROM WET ETCH BAY AND NEAR LITHO WET BENCHES.
- Do not open the door emergency exits unnecessarily

# Cleanroom Don’t’s

- Do not open the door to the cleanroom for communication or passing of products back and forth – use the pass-through instead.
- Do not congregate. No running and try to maintain silence

© Can Stock Photo - csp3629375

# General Rules

- **Rules and policies are no substitute for common sense. Please note that strict action will be taken against those violating the rules**
- **Do not start when in doubt.**
- **Keep good house keeping habits.**
- **DO NOT WORK ALONE, or when stressed or not well.**
- **Cleanroom hours: 6 am to  2am (24x7 on some tools), all 7 days of a week**
- **Please contact any of the management representatives if you have suggestions or feedback**

# Access

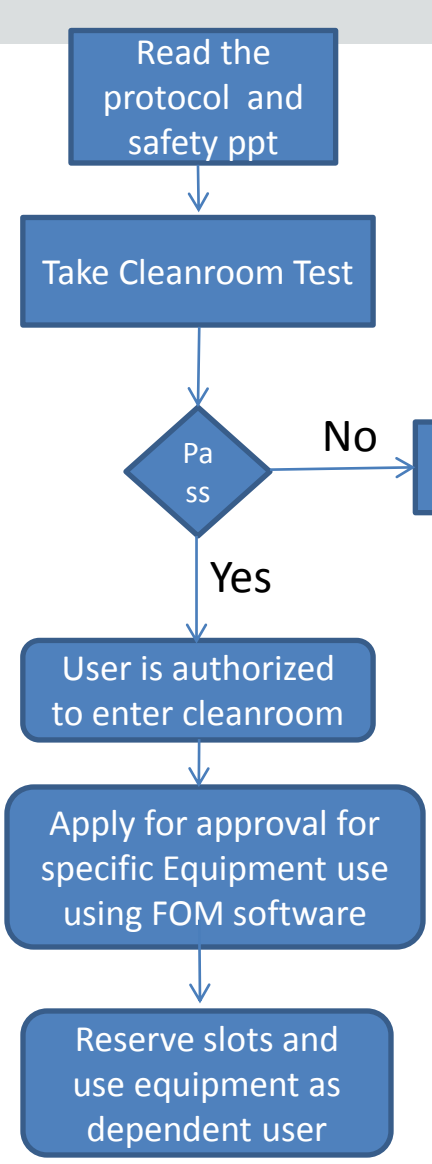

- **Download the authorization form**
- **Fill, sign and submit it.**
- **Read clean room protocols and safety documents.**
- **Take the clean room test.**
- **PASS IT, you are in!**

**Authority to enter does not mean authority to operate instruments**

# Equipment usage

- **Two type of users: Dependent/ Independent**
- **Dependent authorized users: Only day time access / process done by facility technologist, please book the slot well in advance**
- **Independent users: Anytime access, after proper training**
- **Talk to your supervisor and the concerned technologist if you need to be an independent user.**
- **Internet usage (including FOM) on equipment computers strictly prohibited. Use of pendrives is also not allowed, use winSCP to transfer data**

# How to Become An Authorized User

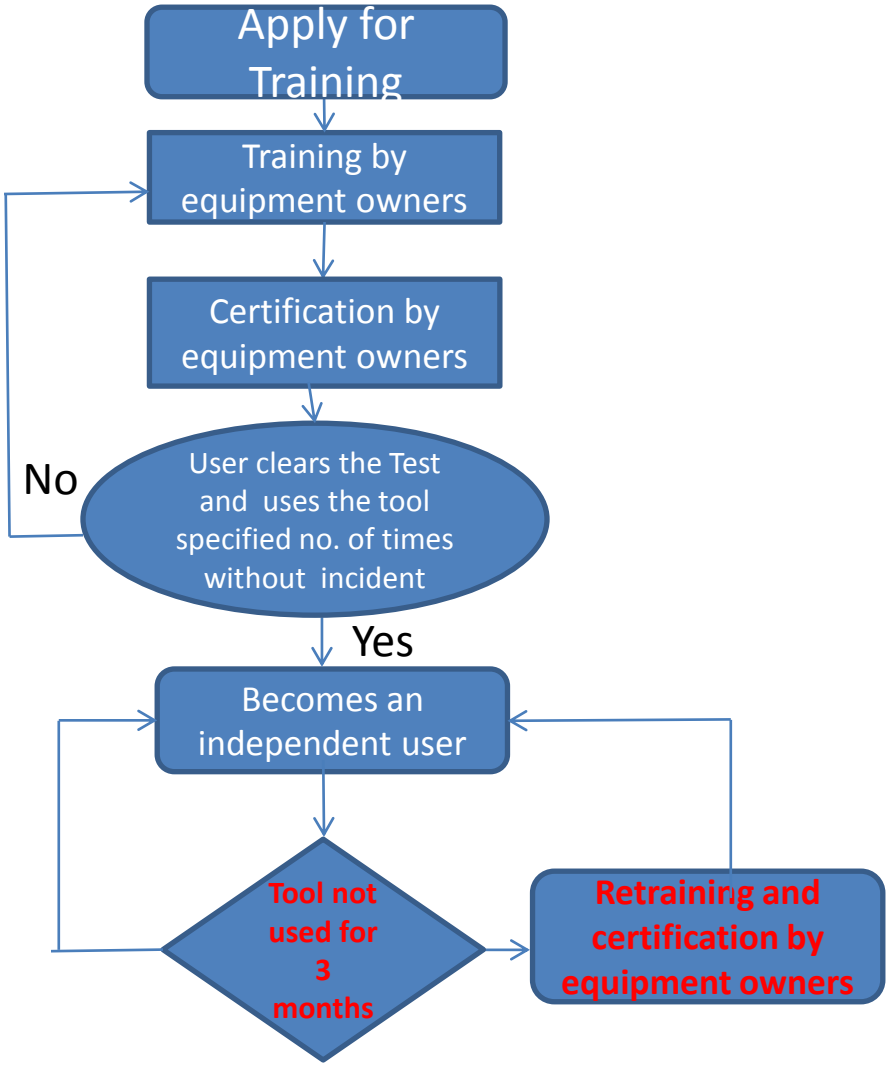



**Repeated 3 times only**

Users not passing the test even after 3 attempts should send an email to Dr. Prabhakara Rao and the decision will be taken by the clean room committee

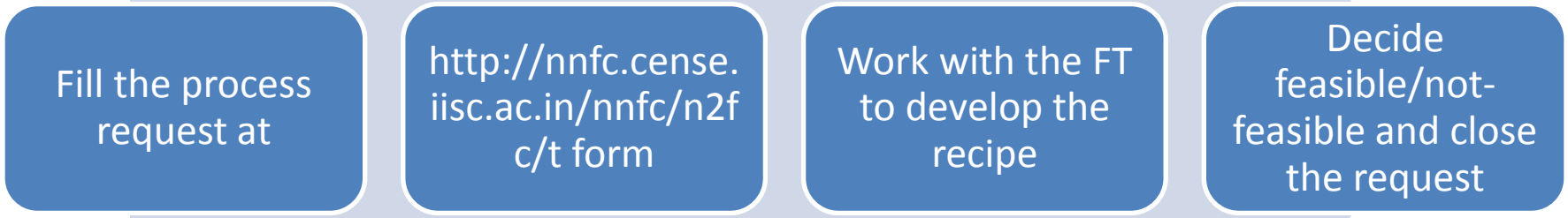
Dependent users are temporary users (those who will not use the tool more than 3 times)

# How to Become An Independent User



# Need a process? (New Process Request)

- **All new recipes need to be documented.**
- **Procedure**




- **In order to access the Online Process Request System, all potential users are requested to register at http://nnfc.cense.iisc.ac.in/nnfc/n2fc**
- **Click on "Member Login", to register yourself. Once registered, please follow the instructions on the Member Dashboard to submit a process request.**
- **All details pertaining to Process Request Submission and Process Request Execution are available in the "Process Request Procedure" Document on the Member /Faculty Dashboard.**
- **Please send the form 2 week in advance of your reservation**

# Procedure for withdrawal of Materials (from the NNFC stores)

- **Only those registered on FOM can purchase materials**
- **For withdrawals of item like Silicon wafers, consumables like tweezers etc.**

Fill the online withdrawal form available at NNfC website→Quick links→Consumable withdrawal/Wafer withdrawal form

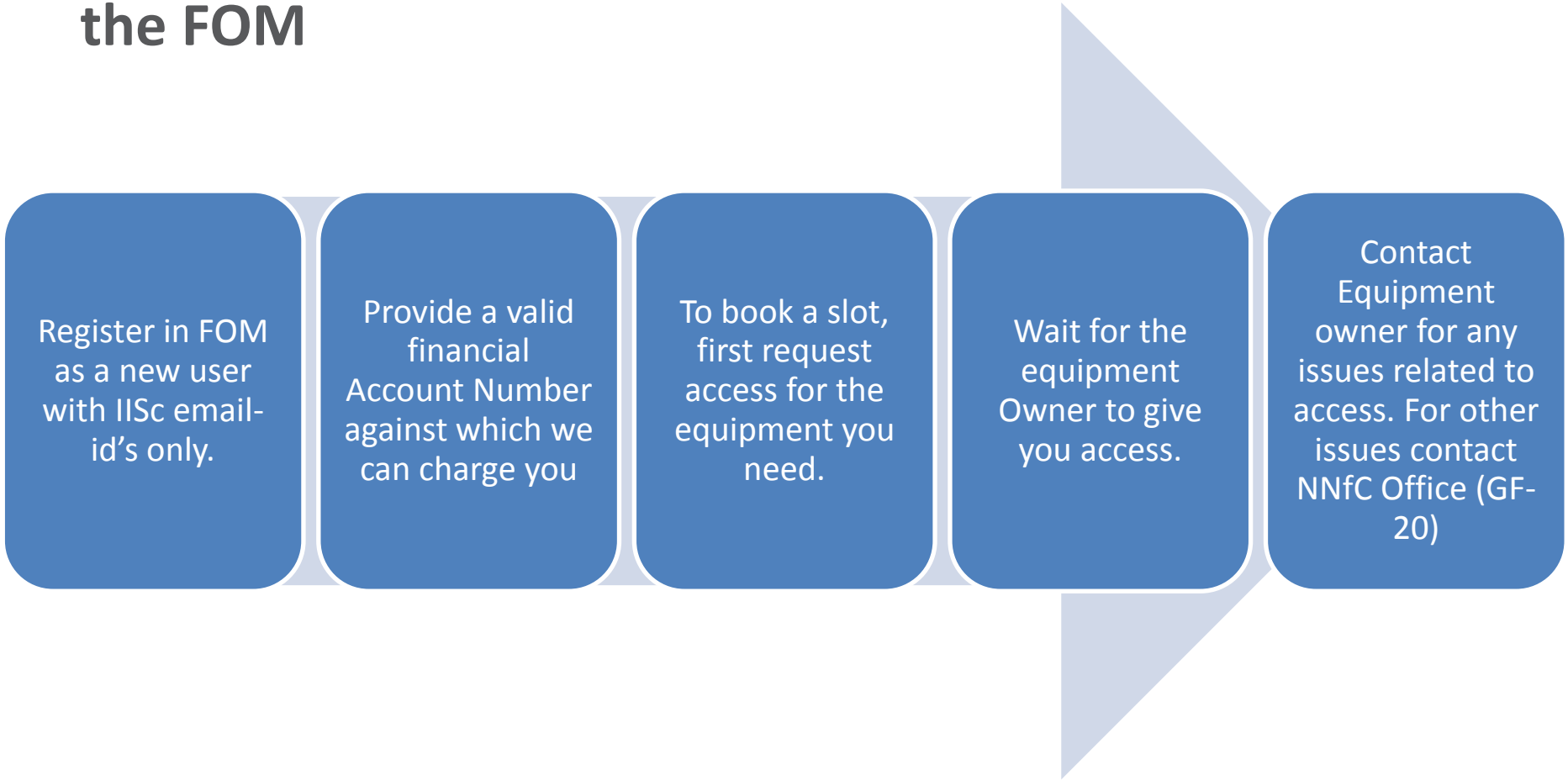
Needs approval from Supervisor and NNFC office (COO)

Wafers can be obtained from inside the cleanroom between 3.00 and 3.30pm

Consumables to be obtained from plenum storage area between 2.30-3.00pm.

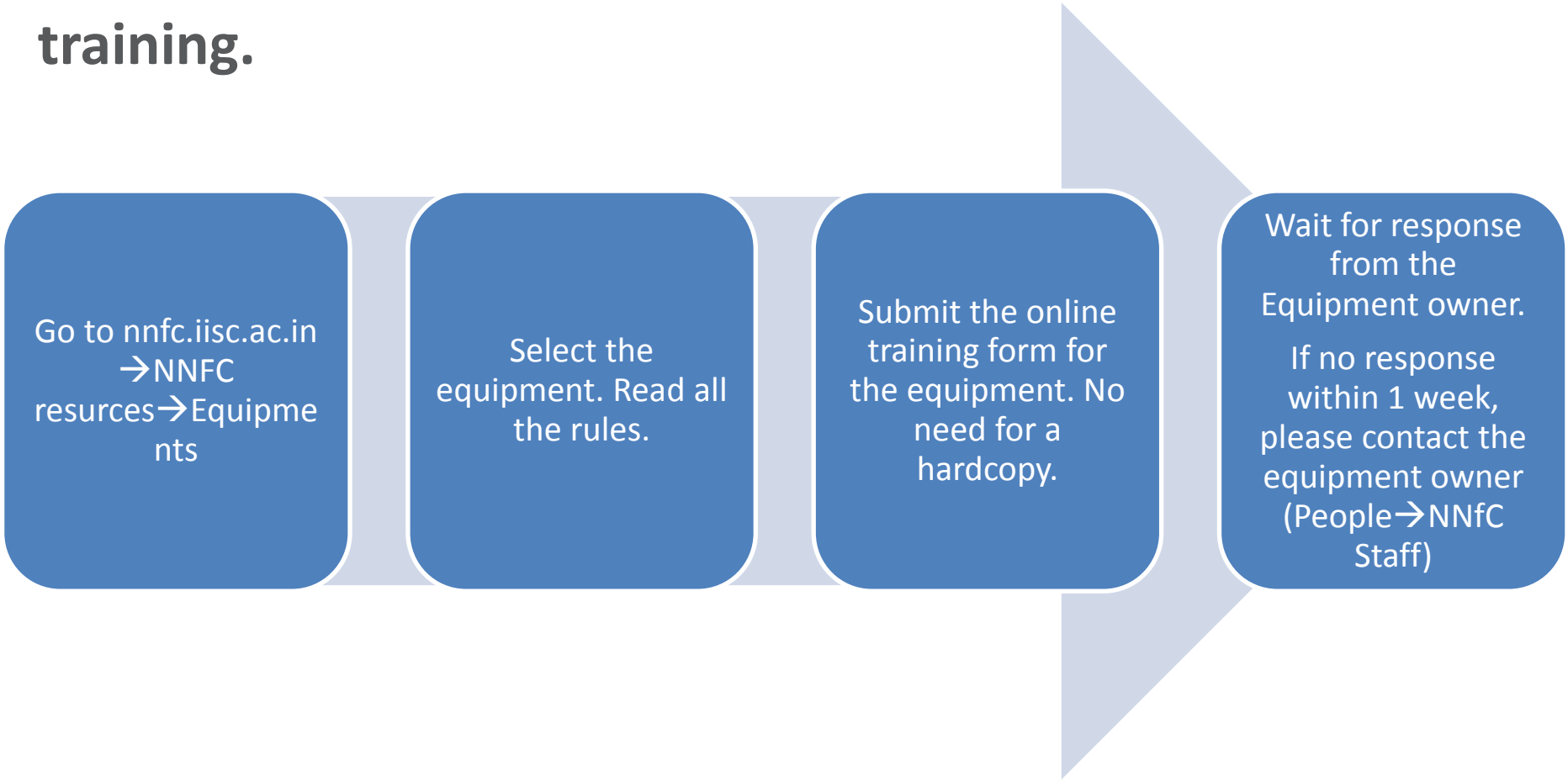
# Procedure for booking Slot in FOM

- **Only those who have biometric- access can register in the FOM**



# Procedure For Getting Trained on an Equipment

- **Only those who have biometric-access can register for training.**



# Applying for tools ***except*** Dektak, Ellipsometer and Wet etch

NNFC website → NNFC resources → Equipment required

Tool Safety Level:


**Process Capability** **Tool Capability** **Tool Location** **SOP**

**Training Schedule** **Trend Chart** **People**

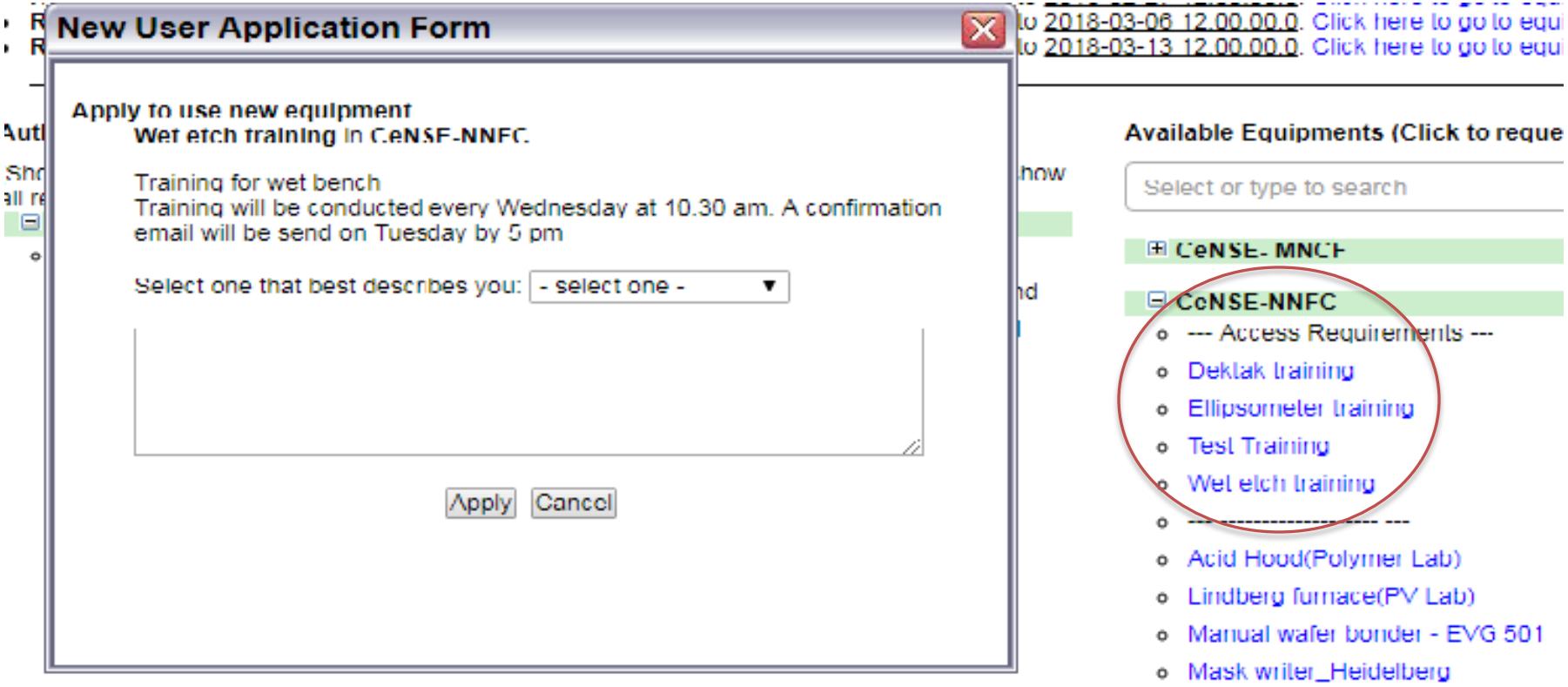
Training Charges - Rs. 5,000 on completion of the training - first 2 slots booked would be free of charge

Click below link for online training form. Users will receive a conformation mail regarding the Date and Time of the Training conducted on the earliest possible Day from the Date User has applied for Training

Cleanroom Equipment Training Form

# Applying for training

- **Wet etch, Dektak and Ellipsometer: Apply through FOM**

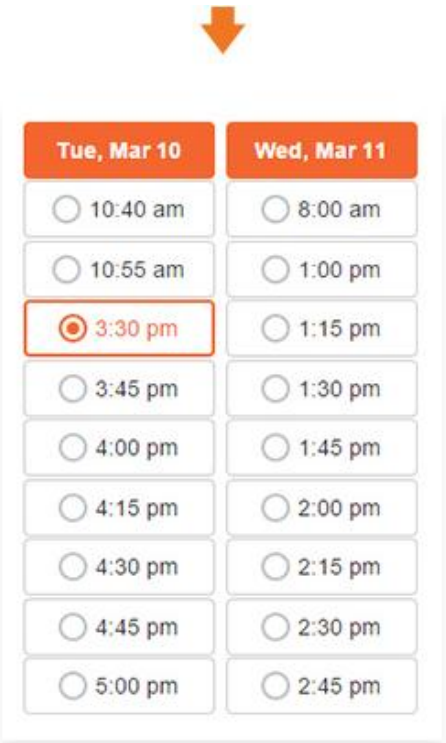


# Loss of access

- **Six months of no activity in the cleanroom automatically removes biometric access**
  - **Take cleanroom safety test and ask for biometric access again**
- **Three months of no tool use will remove independent access**
  - **Ask for retraining**
  - **Retraining might consist of just practice slots or full training depending on the tool**
  - **Talk to the concerned FT**
  - **Plan in advance: FOM alert will be sent**

# Slot Bookings

- **Slots need to booked using FOM software before tool usage.**
- **Be there with your sample 15 min before your booking starts, 30 minutes before a litho slot**
  - **Samples submitted 10 min after the beginning of the slot will not be accepted**
- **If you book, but do not turn up, penalty points as per norms**
  - **Also, the slot will be charged**



# Slot cancellation on FOM

- **Slots booked on FOM will not be honored if**
  - Slots booked by dependent users using express logon
  - Slots booked by dependent users after official hours
  - **Slots booked without relevant information**
    - **Process conditions**
    - **Materials information (different layers, pre process)**
  - Slots booked by users who are under suspension from the cleanroom

# In case of tool break down

- **Inform the concerned facility technologist (phone numbers available near the phones in the bay)**
  - **Call from outside the fab incase of network problem**
- **Send 'Instrument problem report' to the instrument managers using FOM**
  - **Log off and press the "something wrong" button**
- **If unable to contact FT's, please put the tool down notice and send an email to the FT and technology manager**
- **DO NOT TRY TO REPAIR BY YOURSELF**

FOM
Facility Online Manager

Time on server
Tuesday Jan. 19
15 : 13 : 05

» Admin Home
» User Home
» Chemical CMOS I
» Departments
» Supervisors
» Resources Admin
» Maint. Records
» Users Admin
» Email List
» Collaborate & Service
» Usage Records
» Purchase Supplies
» Documents
» User Report
» My Profile
» My Accounts
» Contact Manager
» Logout
» User Forum

**Notes from instrument manager**

Dependent slots allowed only between 10 am to 1pm and 2pm to 5 pm

**Instrument Schedule: Chemical CMOS Non Metal Bench**

Day View Month View

**Chemical CMOS Non Metal Bench - Logoff**

**Chemical CMOS Non Metal Bench - Logoff**

- ○ For repair
- ○ For maintenance
- ○ For training
- ○ For paid service research
- ◉ My own research

Instrument Status Report: ○ OK ◉ Something wrong

Select the Account Number you want to use for this session:

- ☑ Admin_Use (100%)
- ☐ Material analysis

Comment:

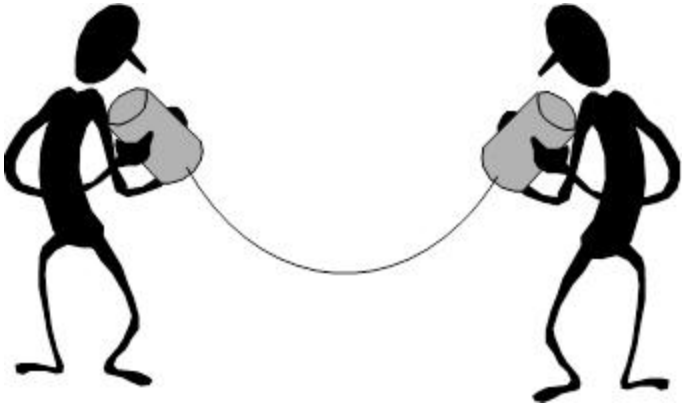
Logoff

11/23 Today Jan 19, 2016 01/25 02/01 02/08 02/15 02/22 02/29 03/07 03/14

| Mon 0 | | | Thu 01/21 | Fri 01/22 | Sat 01/23 | Sun 01/24 |
|---|---|---|---|---|---|---|
| | | | Click to show sessions from midnight to 06:00 | | | |
| 06:00 | | 30 | 06:00 - 06:30 | 06:00 - 06:30 | 06:00 - 06:30 | 06:00 - 06:30 |
| 06:30 | | 00 | 06:30 - 07:00 | 06:30 - 07:00 | 06:30 - 07:00 | 06:30 - 07:00 |
| 07:00 | | 30 | 07:00 - 07:30 | 07:00 - 07:30 | 07:00 - 07:30 | 07:00 - 07:30 |
| 07:30 | | 00 | 07:30 - 08:00 | 07:30 - 08:00 | 07:30 - 08:00 | 07:30 - 08:00 |
| 08:00 | | 30 | 08:00 - 08:30 | 08:00 - 08:30 | 08:00 - 08:30 | 08:00 - 08:30 |
| 08:30 | | 00 | 08:30 - 09:00 | 08:30 - 09:00 | 08:30 - 09:00 | 08:30 - 09:00 |
| 09:00 | | 30 | 09:00 - 09:30 | 09:00 - 09:30 | 09:00 - 09:30 | 09:00 - 09:30 |
| 09:30 | | 00 | 09:30 - 10:00 | 09:30 - 10:00 | 09:30 - 10:00 | 09:30 - 10:00 |
| 10:00 | | 30 | 10:00 - 10:30 | 10:00 - 10:30 | 10:00 - 10:30 | 10:00 - 10:30 |
| 10:30 | | 00 | 10:30 - 11:00 | 10:30 - 11:00 | 10:30 - 11:00 | 10:30 - 11:00 |
| 11:00 | | 30 | 11:00 - 11:30 | 11:00 - 11:30 | 11:00 - 11:30 | 11:00 - 11:30 |
| 11:30 | | 00 | 11:30 - 12:00 | 11:30 - 12:00 | 11:30 - 12:00 | 11:30 - 12:00 |
| 12:00 | | 30 | 12:00 - 12:30 | 12:00 - 12:30 | 12:00 - 12:30 | 12:00 - 12:30 |
| 12:30 | | 00 | 12:30 - 13:00 | 12:30 - 13:00 | 12:30 - 13:00 | 12:30 - 13:00 |
| 13:00 | | 30 | 13:00 - 13:30 | 13:00 - 13:30 | 13:00 - 13:30 | 13:00 - 13:30 |
| 13:30 | | 00 | 13:30 - 14:00 | 13:30 - 14:00 | 13:30 - 14:00 | 13:30 - 14:00 |
| 14:00 | | 30 | 14:00 - 14:30 | 14:00 - 14:30 | 14:00 - 14:30 | 14:00 - 14:30 |
| 14:30 | | 00 | 14:30 - 15:00 | 14:30 - 15:00 | 14:30 - 15:00 | 14:30 - 15:00 |
| 15:00 | | nal, 15:00-16:00 /Sabiha/RCA 4 wafer Qty 4 | 15:00 - 15:30 | 15:00 - 15:30 | 15:00 - 15:30 | 15:00 - 15:30 |
| 15:30 | | | 15:30 - 16:00 | 15:30 - 16:00 | 15:30 - 16:00 | 15:30 - 16:00 |
| 16:00 | | 30 | 16:00 - 16:30 | 16:00 - 16:30 | 16:00 - 16:30 | 16:00 - 16:30 |
| 16:30 | | 00 | 16:30 - 17:00 | 16:30 - 17:00 | 16:30 - 17:00 | 16:30 - 17:00 |
| 17:00 | | 30 | 17:00 - 17:30 | 17:00 - 17:30 | 17:00 - 17:30 | 17:00 - 17:30 |
| 17:30 | | 00 | 17:30 - 18:00 | 17:30 - 18:00 | 17:30 - 18:00 | 17:30 - 18:00 |
| 18:00 | | 30 | 18:00 - 18:30 | 18:00 - 18:30 | 18:00 - 18:30 | 18:00 - 18:30 |
| 18:30 - 19:00 | 18:30 - 19:00 | 18:30 - 19:00 | 18:30 - 19:00 | 18:30 - 19:00 | 18:30 - 19:00 | 18:30 - 19:00 |
| 19:00 - 19:30 | 19:00 - 19:30 | 19:00 - 19:30 | 19:00 - 19:30 | 19:00 - 19:30 | 19:00 - 19:30 | 19:00 - 19:30 |
| 19:30 - 20:00 | 19:30 - 20:00 | 19:30 - 20:00 | 19:30 - 20:00 | 19:30 - 20:00 | 19:30 - 20:00 | 19:30 - 20:00 |
| 20:00 - 20:30 | 20:00 - 20:30 | 20:00 - 20:30 | 20:00 - 20:30 | 20:00 - 20:30 | 20:00 - 20:30 | 20:00 - 20:30 |
| 20:30 - 21:00 | 20:30 - 21:00 | 20:30 - 21:00 | 20:30 - 21:00 | 20:30 - 21:00 | 20:30 - 21:00 | 20:30 - 21:00 |
| 21:00 - 21:30 | 21:00 - 21:30 | 21:00 - 21:30 | 21:00 - 21:30 | 21:00 - 21:30 | 21:00 - 21:30 | 21:00 - 21:30 |
| 21:30 - 22:00 | 21:30 - 22:00 | 21:30 - 22:00 | 21:30 - 22:00 | 21:30 - 22:00 | 21:30 - 22:00 | 21:30 - 22:00 |
| 22:00 - 22:30 | 22:00 - 22:30 | 22:00 - 22:30 | 22:00 - 22:30 | 22:00 - 22:30 | 22:00 - 22:30 | 22:00 - 22:30 |
| 22:30 - 23:00 | 22:30 - 23:00 | 22:30 - 23:00 | 22:30 - 23:00 | 22:30 - 23:00 | 22:30 - 23:00 | 22:30 - 23:00 |
| 23:00 - 23:30 | 23:00 - 23:30 | 23:00 - 23:30 | 23:00 - 23:30 | 23:00 - 23:30 | 23:00 - 23:30 | 23:00 - 23:30 |

# Communications from the Cleanroom

- **FOM sends a notice to all users**
  - **Make sure your registration email is your official IISc email id**
  - **Notices cannot be send to other gmail, yahoomail etc**
- **General email to all CENSE users**
- **Broadcast emails send to IISc**
- **Notice on NNFC webpage, FOM “users note”**



# Responsibility of the user

- **Proper and professional conduct**
- **Not cause disturbance or disrupt the procedures of other users**
- **Report any violation noticed immediately to the Nanofab staff**
- **It is the responsibility and need of each user that the fab is maintained at the optimum levels**

# User agreement

- **All are expected to sign USER Agreement before becoming authorised USER**

- **Violations of Nanofab protocol and procedures**
  - **penalty points and restricted access and privileges**

# Violation of Rules

- **Depending on the gravity of violation**
  - **You *may* get just a warning**
  - **You may get your booking cancelled**
  - **You may loose your registration for a short while**

  **Or**

  **You may loose your clean room registration all together!**


REMEMBER, monitoring cameras are everywhere in the clean room!

**Rules apply 24X7**

# Penalty point chart

| Cumulative penalty points | Disciplinary action |
|---|---|
| >/=30 points | One week suspension |
| >60 points | Two week suspension full cleanroom |
| >90 points | 3 week suspension, no cleanroom access |
| >100 points | Barred from access to the cleanroom, case to go to Cleanroom committee |

http://nnfc.cense.iisc.ac.in/


# SAFETY IN THE CLEANROOM

Folowing cleanroom and safety protocol in the cleanroom is essential for both user and fellow users of the facility. All the users are bound to follow the rules and regulations without any reservation.

A copy of the NNfC safety training can be accessed here.

A copy of the NNfC cleanroom protocol can be accessed here.

Annual Safety Test question paper can be accessed here.

Safety Protocols on Youtube :