NNFC Cleanroom protocols

National Nano Fabrication Centre(NNFC)

Centre for Nanoscience and Engineering(CeNSE)

Indian Institute if science(IISc)

Bangalore-12

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Introduction

- **What is a clean room?**

As per ISO standard-14644-1:2015

"Room in which the number of airborne particles is controlled and classified, and which is designed, constructed and operated in a manner to control the introduction, generation and retention of particles inside the room and in which other relevant parameters such as temperature ,humidity, pressure are controlled as necessary"

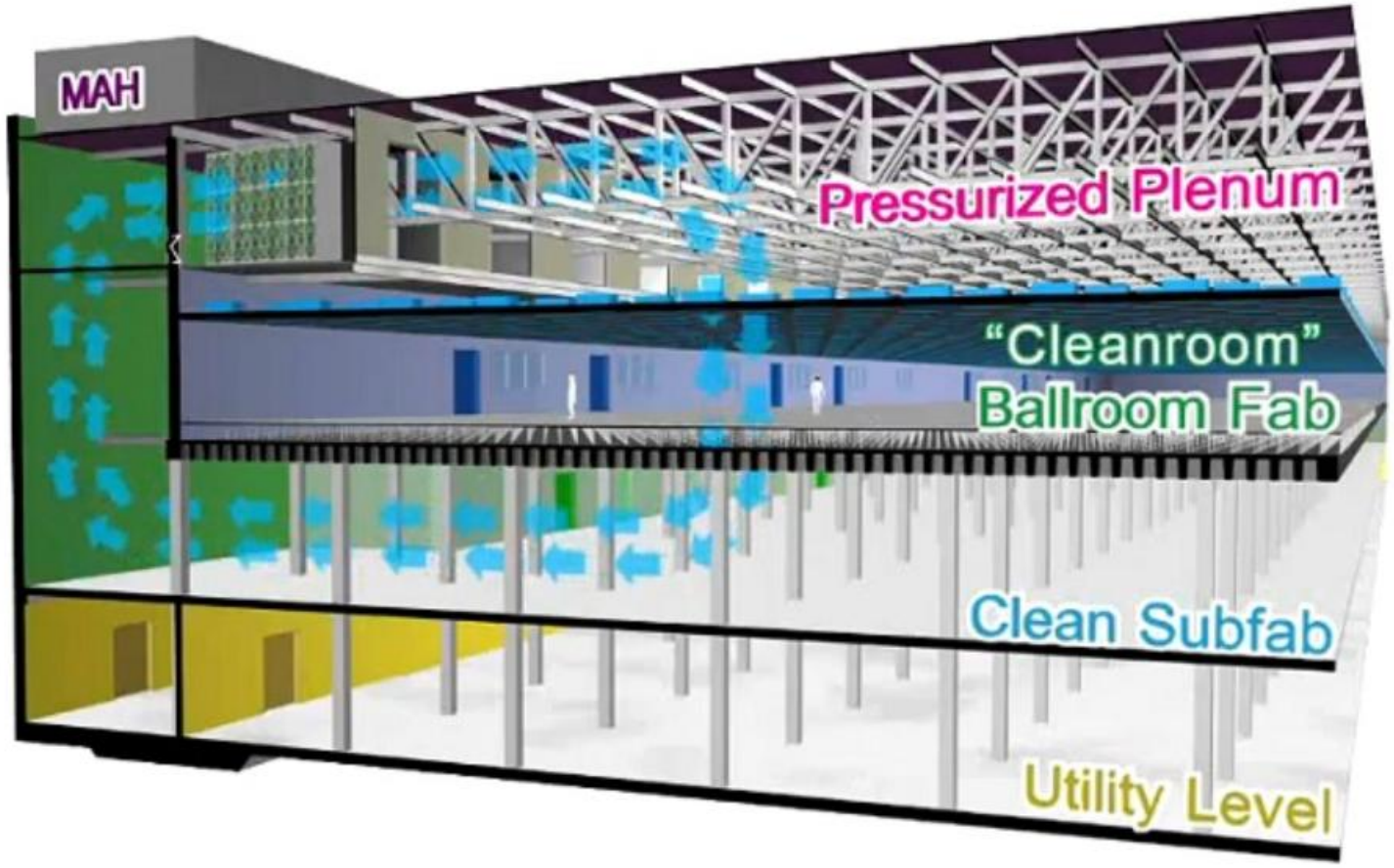
- **Why cleanroom training?**

➢ *The Clean room environment is carefully maintained at particular standards and has equipment's which are delicate and precisely calibrated*

➢ *The chemicals and gases used in the facility may be extremely hazardous*

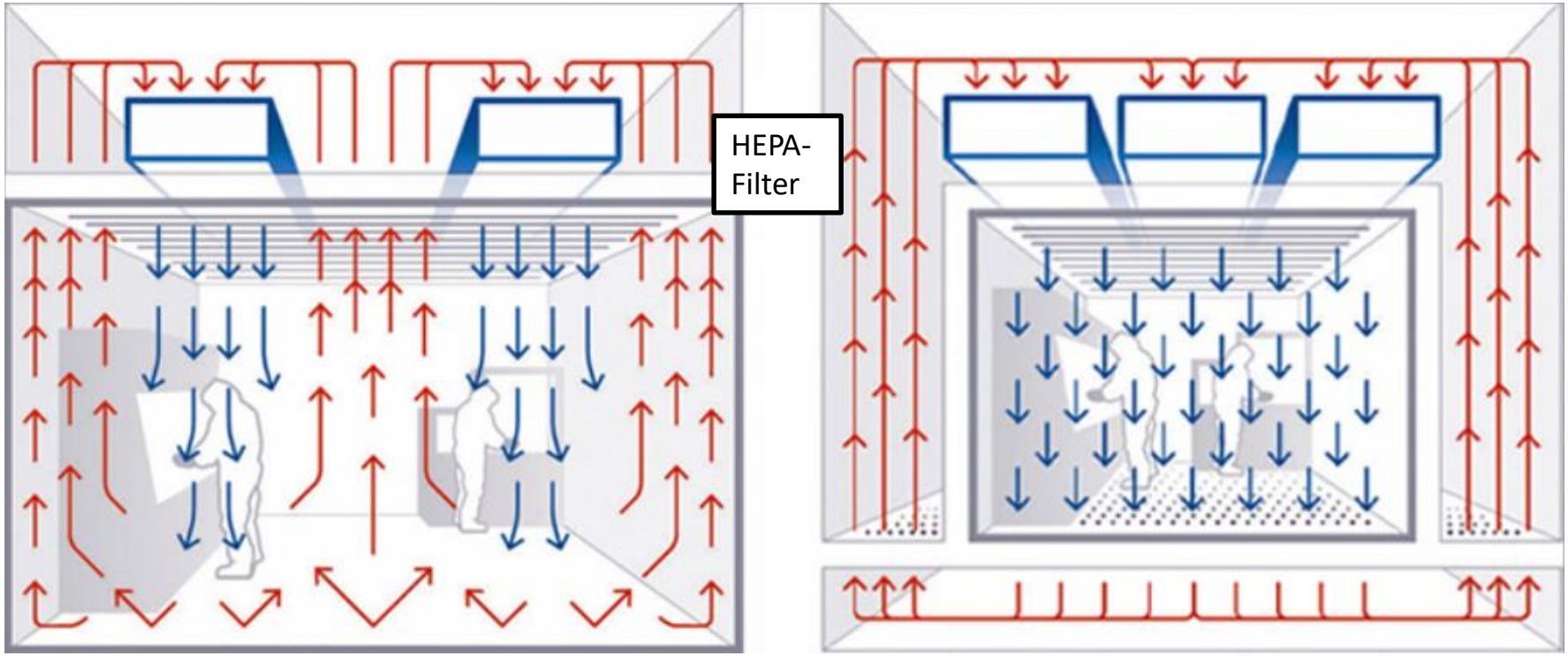
➢ *Mis-use may lead, not only to destruction/malfunctioning of the device, but could also pose danger to personnel/instrument*

Cleanroom structure



INTEL AND MICRON 25NM FLASH MEMORY PRODUCTION

Principles of the Clean Environment



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

NNFC-8000 sq.ft area

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

NNFC-2000 sq ft area Lithography Area

Cleanroom Classification

Level of cleanliness is defined by ISO or FED standards

ISO 14644-1 Cleanroom Standards

www.portafab.com/cleanrooms.html

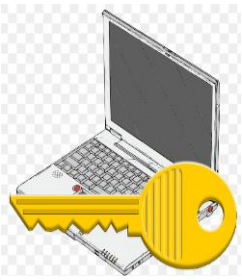
Class	maximum particles/m^3						FED STD 209E equivalent
	≥0.1 µm	≥0.2 µm	≥0.3 µm	≥0.5 µm	≥1 µm	≥5 µm	
ISO 1	10	2.37	1.02	0.35	0.083	0.0029	
ISO 2	100	23.7	10.2	3.5	0.83	0.029	
ISO 3	1,000	237	102	35	8.3	0.29	Class 1
ISO 4	10,000	2,370	1,020	352	83	2.9	Class 10
ISO 5	100,000	23,700	10,200	3,520	832	29	Class 100
ISO 6	1.0×10^6	237,000	102,000	35,200	8,320	293	Class 1,000
ISO 7	1.0×10^7	2.37×10^6	1,020,000	352,000	83,200	2,930	Class 10,000
ISO 8	1.0×10^8	2.37×10^7	1.02×10^7	3,520,000	832,000	29,300	Class 100,000
ISO 9	1.0×10^9	2.37×10^8	1.02×10^8	35,200,000	8,320,000	293,000	Room air

Cleanroom Conduct-Responsibility of the User

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

Cleanroom Protocols

- **Hours of Operation**
  - -Cleanroom is operational 24x7 on all tools except Wet benches.
  - - They are unavailable everyday from 2 A.M. to 6 A.M
- **Access- follow the below steps..!!**



Download the authorization form NNFC website

1.Fill, sign and submit the same to NNFC office

2.Read clean room protocols and safety documents.

3.Take the clean room test.-You have only 3 attempts ….!!!/ If not you have to wait for six months for retest.

4.PASS IT, attend orientation, you will be given access by CeNSE office staffs!

Note: Authority to enter does not mean authority to operate equipment's..!!!

- **New User Orientation**
  - **-online and available in NNFC website.**

Cleanroom Entry Protocols-after Access..!!

- 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/friends 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.**

Before every entry to cleanroom..

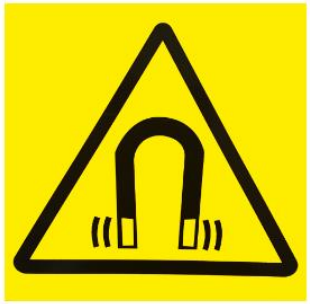
- Please wash your hands and face with lots of water and dry before coming into the clean room
- If you ate something just before coming into the cleanroom, drink water and rinse your mouth thoroughly

- If you smoke, drink water before coming into the cleanroom
- Do not come in with torn and/or dirty socks/ stinky foot wares.

Before every entry to cleanroom..

- Wear Clean and dry clothes .
- Churidhars ,Salwars T-Shirts are allowed.
- Clean socks or stockings are mandatory.-wear the foot covers ..!!
- Please make sure that long or medium length hair is tied back.-open hair entry is restricted

“Contact lenses are strictly prohibited”



- People with pacemakers or any metal implants and pregnant women should consult NNFC office before you proceed.

Before every entry to cleanroom: Not allowed

- Clothes which are dusty, dirty or wet ,avoid entry with sweet stinky body
- Sleeveless clothes, shorts or short-pants
- Tank tops, halter tops and sphagetti strap tops, sarees, shorts, skirts and gowns

- Clothes which shred fiber like fur, mohair etc
- Deodorants, perfumes , kajals and cosmetics including hand cream
- Heavy jewellery and decorative accessories including flowers
- People suffering from cough, cold or respiratory diseases

Cleanroom Don’ts

- ***Cell Phone usage Policy inside cleanroom.***

  - Cell phone use is strictly prohibited inside NNfC

  - Only staffs can use during equipment maintenance/ for any documentation purpose

- ***Do not open the door emergency exits unnecessarily***
- ***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***

EQUIPMENT USE- General Instructions

- 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 pen-drives is also not allowed, use winSCP to transfer data

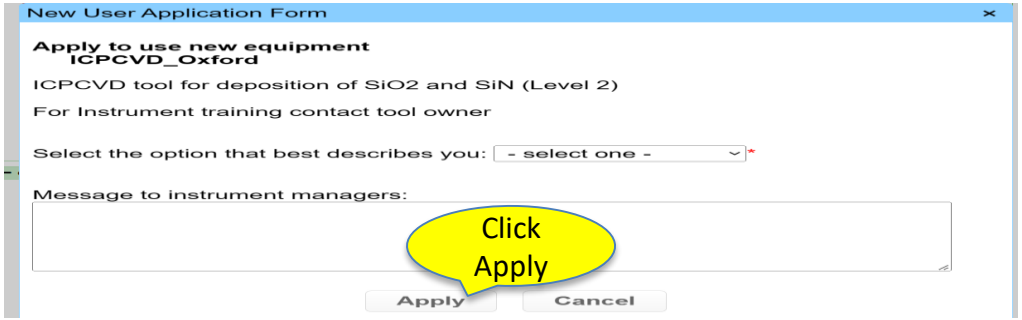
EQUIPMENT USE- Register in FOM

Register in FOM as new user

- Use only IISc email ID
- Provide Valid financial account number

To Book slot in particular Tool

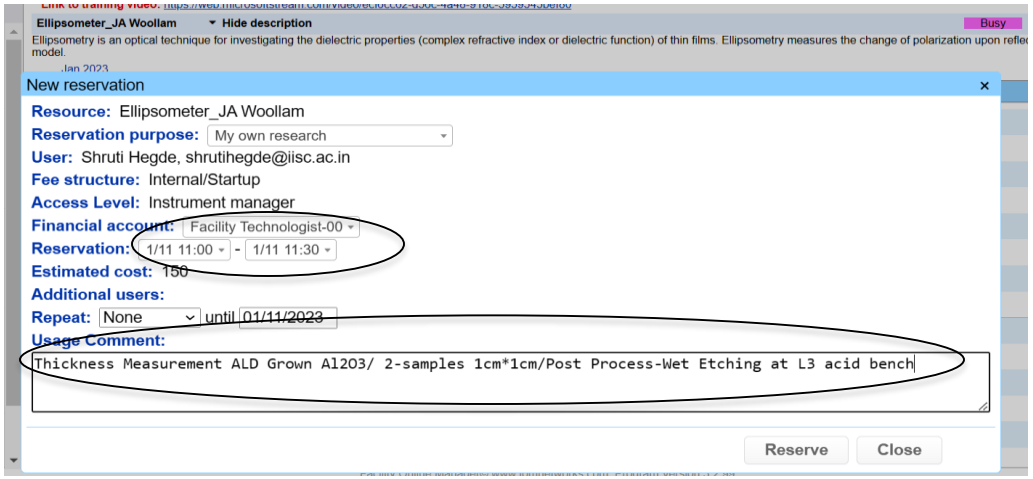
- Request for the access for the same
- Wait for the access from the Equipment owner



Contact Equipment owner for any issues related to access. For other issues contact NNfC Office (GF-20)

EQUIPMENT USE- FOM Slot Bookings

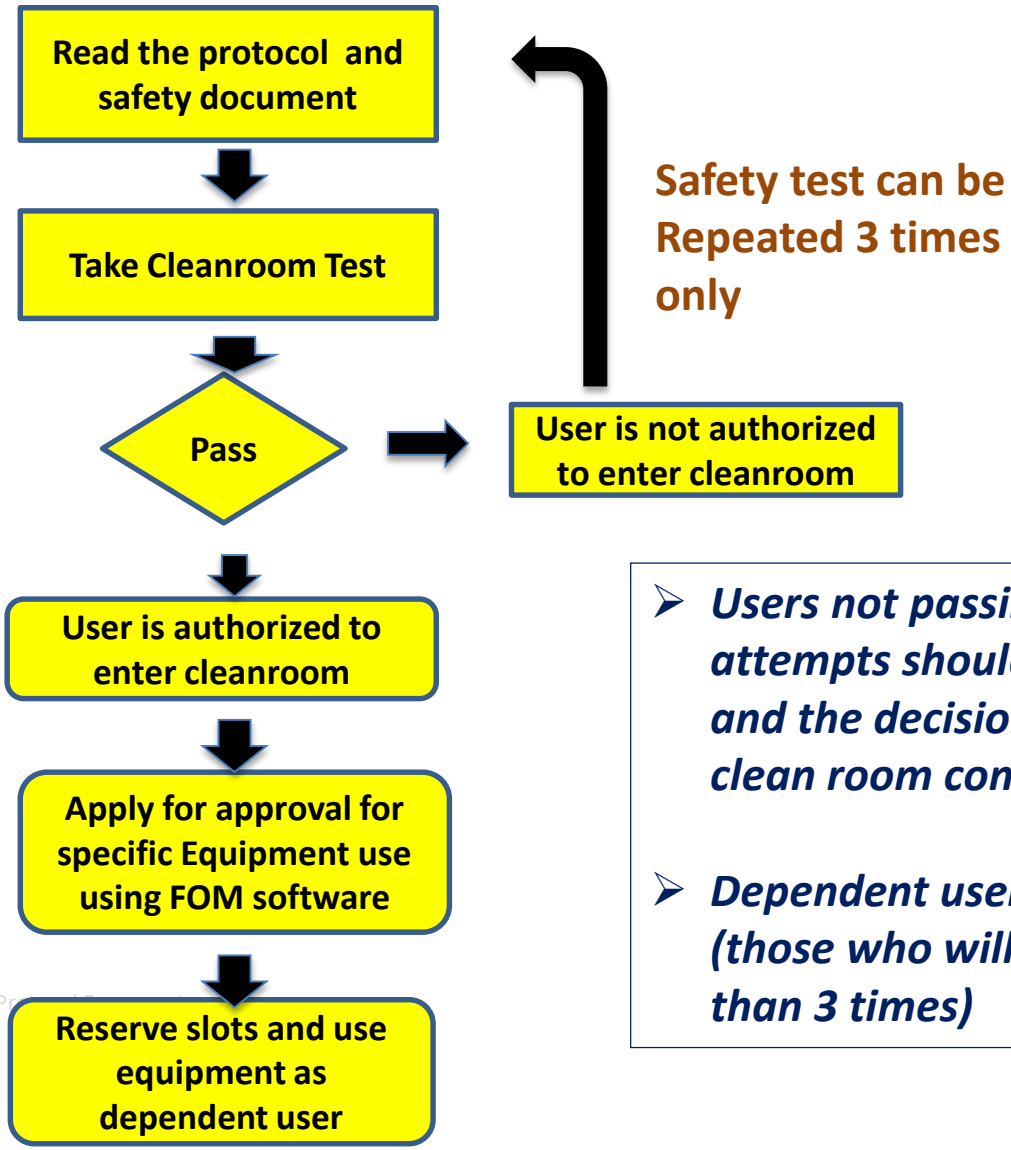
- Slots need to booked using FOM software before tool usage.
- Be there with your sample 15 min before your booking starts, 30 minutes before a litho slot
- Samples submitted 10 min after the beginning of the slot will not be accepted
- If you book, but do not turn up, penalty points as per norms
  -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



EQUIPMENT USE- Slot cancellation on FOM

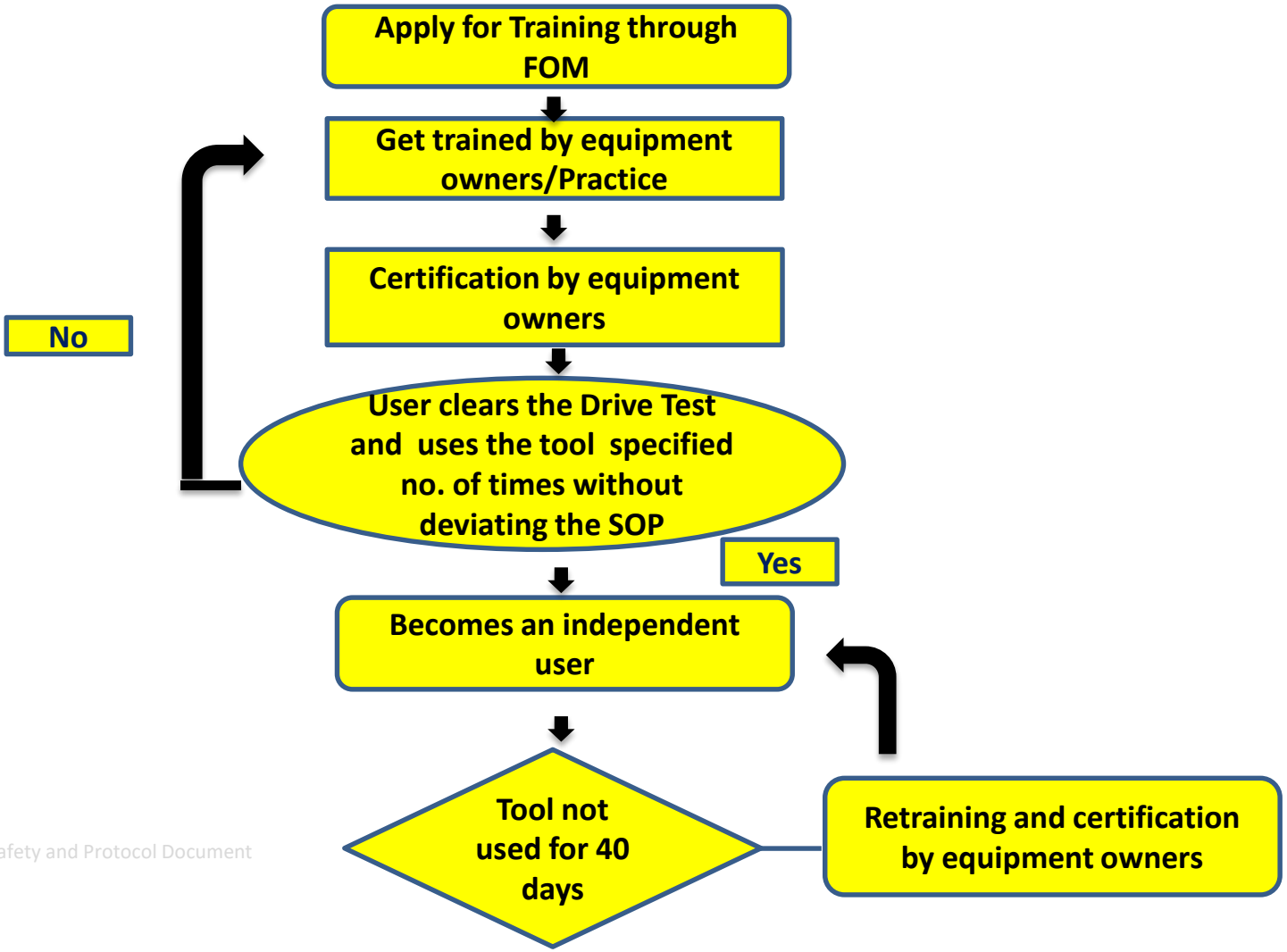
- Slots booked by *dependent* users using *express logon* on FOM will not be honored
- Slots booked by *dependent* users *after office hours (10 AM-1 PM, 2PM-5PM)*
- Slots booked without relevant information, Process conditions, Materials, Number of samples, sample size etc; information (different layers, pre and post process).
- Slots booked by users who are under suspension from the cleanroom
- More than 40% cancellation of user slots on any Tool will leads to Penalty- Will be Calculated every month and submitted to Admin committee.
- 3-no show will be penalized.
- Two different slots can not be booked in the same time

EQUIPMENT USE- How to Become An Authorized User



- ***Users not passing the test even after 3 attempts should send an email to COO 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)***

EQUIPMENT USE- How to Become An Independent User



EQUIPMENT USE- How apply for particular tool training.

Except WET Etch, all other tools apply through office training request form,

- E-Beam evaporator (LEYBOLD) Day time user **Available**

  Slots are now open for five materials - Au,Ti,Cr,Ni & Al. Dependent users have to book a minimum of 3 hours for maximum of 2 stack. Four stack slot requires minimum of 4 hours.Argon Ion etching is available. Please join 'leybold' users group in outlook for communications.

  WHILE BOOKING THE SLOT KINDLY MENTION SUBSTRATE DETAILS, deposited material, thickness, PRE PROCESS DETAILS, ELSE THE SLOT WILL BE CANCELLED WITHOUT PRIOR NOTICE AND PENALTY POINTS WILL BE ADDED FOR SECOND VIOLATION.

  Inadequate slot details and not filling up the invoice spreadsheet will lead to penalty points.

  For overnight vacuum, the entire slot from the time loaded counts, till the end of the slot.

  Dependent users can take only a maximum of 3 FT dependent slots.

  Training Video for practice slots:
  https://web.microsoftstream.com/channel/1da1db3d-c58c-4eba-adec-13d51b065c0a

  Training/Practice Form: *https://forms.office.com/r/8W6rsn8RPW*

  STANDARD OPERATING PROCEDURE -
  http://facilitybooking.cense.iisc.ernet.in/fom/downloadFile?fn=LEYBOLDE_BEAMSOPRevD_2.docx

  Users can deposit a maximum of 100 nm of Au per slot, if thickness requirement exceeds the same kindly contact FT before booking slots.

Click and fill up the form, you will get response from respective Tool Owners.

EQUIPMENT USE- How apply for particular tool training.

For Wet Etch training,

You can apply through FOM, so that your training slots will be reserved.

Hands-on Training slot schedule is as below with required information will be provided on

	Day	Time
Every Week	Tuesday	2.30 p.m to 4.30 p.m
	Thursday	2.30 p.m to 4.30 p.m

Equipment Use-Equipment break down

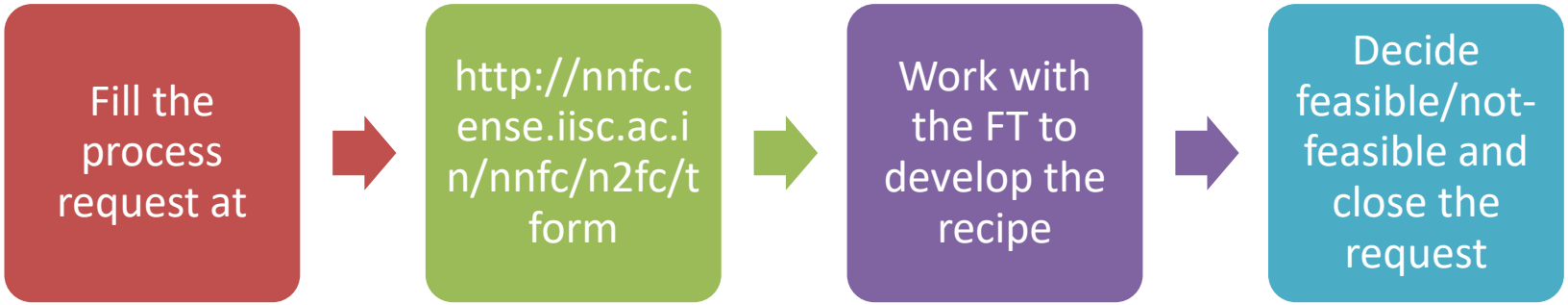
- Inform the concerned facility technologist (phone numbers available near the phones in the bay)

  - Inform the equipment owner by email if it is non office hour.
  - If it is a safety issue immediately inform BMS.-Switch off the Tool by pressing EMO
- 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 and in the User group. So that next users will be updated.

Cleanroom safety and Protocol Document

- DO NOT TRY TO REPAIR BY YOURSELF

EQUIPMENT USE- Need a new process? (Process Request/development)



-In order to raise new process requirement, 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**

How to bring new materials or gadgets accessory tools inside?

For new chemicals:

Email to contamination committee (i.e., Dr. Savitha p, savithap@iisc.ac.in) with attached MSDS and purpose of the use with pre and post process details.

-Show the clearance note to required cleanroom staff

For gadgets accessory tools :

- Email to COO of NNFC i.e., Dr. Savitha p, savithap@iisc.ac.in)

- Describe purpose and size of the device.

-Also inform clean room staff the same

-Provide the documentation for use and storage place.

Contamination in cleanroom- 3 categories

- Molecular contaminants

- Surface contaminants

- Particulate contaminants

Airborne molecular contamination (AMC) sources

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

AMC contamination can ruin,

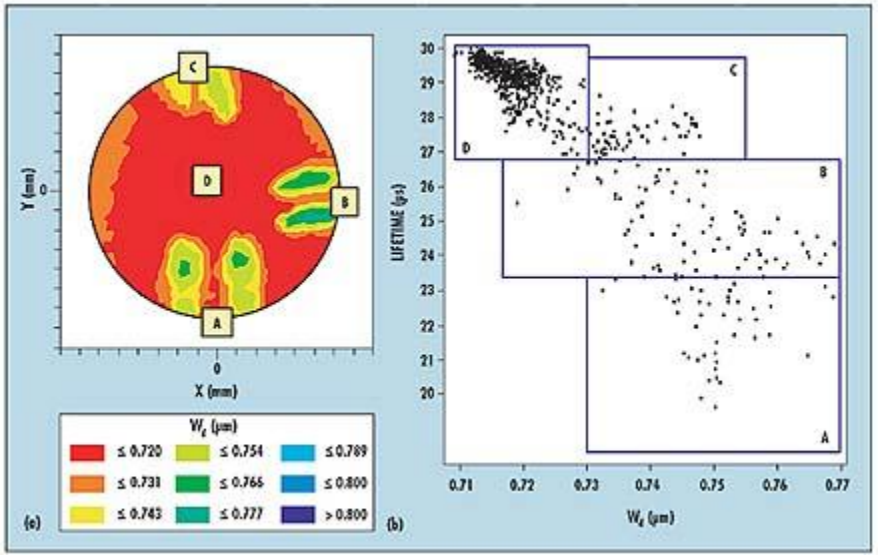
-Devices and circuits

-Production yield.

-Process reliability

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

Particulate contamination can ruin,

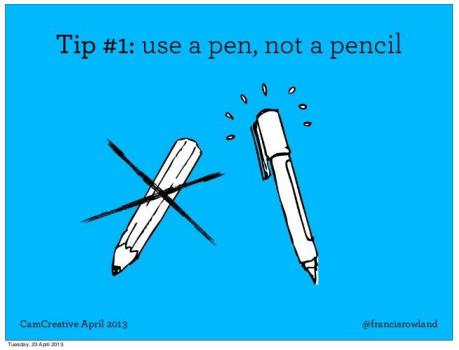
-Devices and circuits

-Device and equipment controllability.

-Process reliability

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



Cleanroo

Particulate contamination can ruin,

-Device failure-short circuits, pin wholes, open circuits etc;

-Reduce the yield-failed device, many tool hours, fab money

-Mask

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

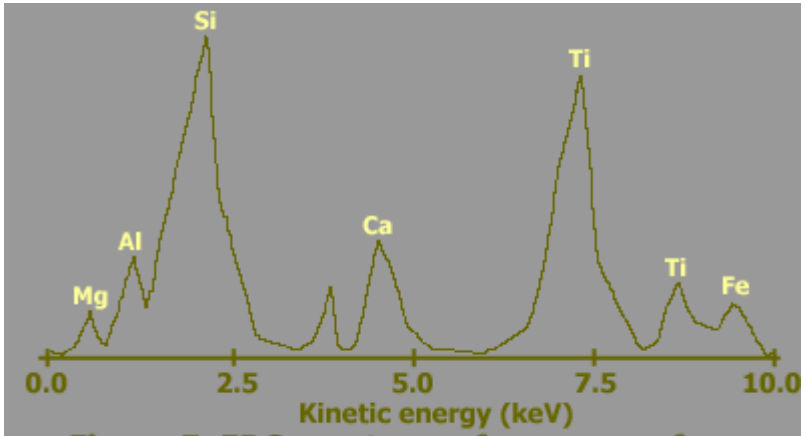


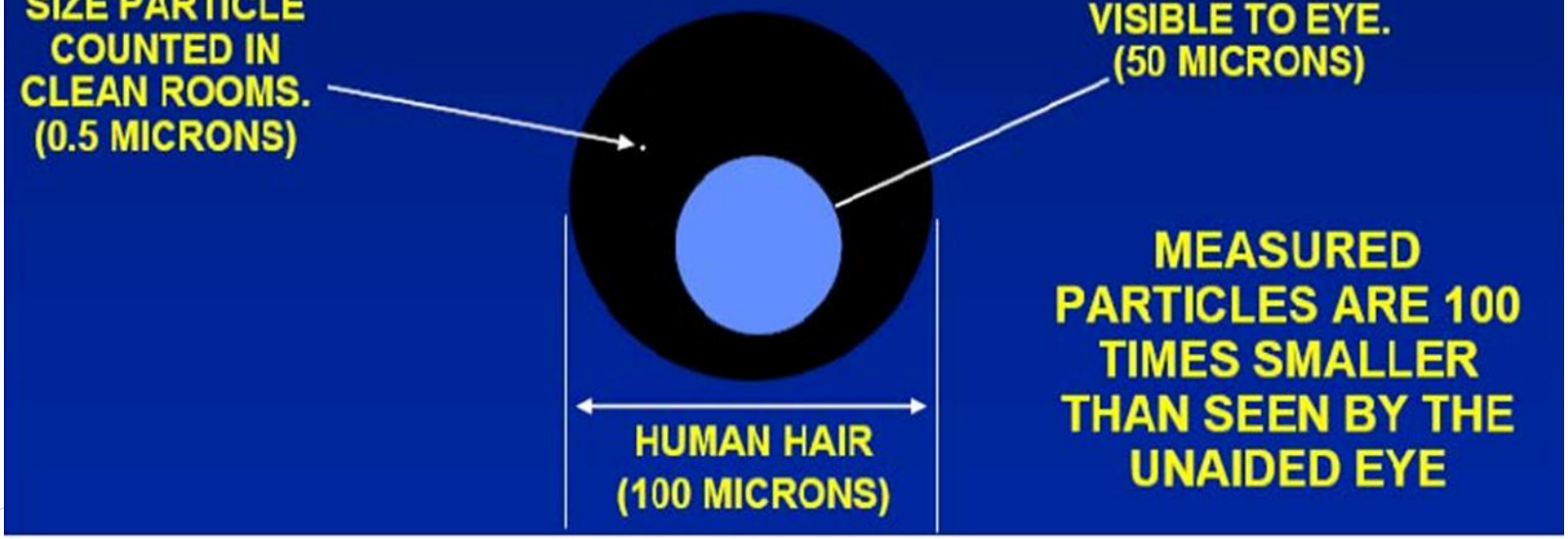
Figure 5. EDS spectrum of a common face powder (residue)

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



Contamination Sources

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

You are the Primary Contaminant!

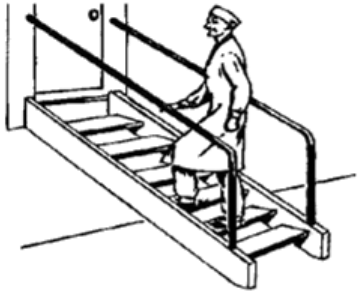
100 000

500 000

1 000 000

2 500 000

5 000 000 - 10 000 000



10 000 000

15 000 000- 30 000 000

[particles/min >0,3µm]

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

Gowning Procedure

Order of Gowning

1. *Put on the Facemask available in the Gowning area*
2. *Followed by Hairnet*
3. *Gown/Bunny suit*
4. *Booties*
5. *Gloves*

De-Gowning Procedure

De-gowning is done in reverse to the gowning procedure – from the feet up.

Note: Properly in place your booties and dispose the Facemask and hairnet to bin

Gowning Procedure

Detailed Gowning /un-gowning 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 few seconds (10-12 sec) 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.**

Procedure for withdrawal of Materials (from the NNFC stores)

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

Wafers can be obtained from inside the cleanroom between 4.30 and 5.00pm

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

Needs approval from Supervisor and NNFC office (COO)

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

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
- 40 days 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

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

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
- Regular updates in the respective user groups in Office 365
- Broadcast emails send to IISc
- Notice on NNFC webpage, FOM “users note”

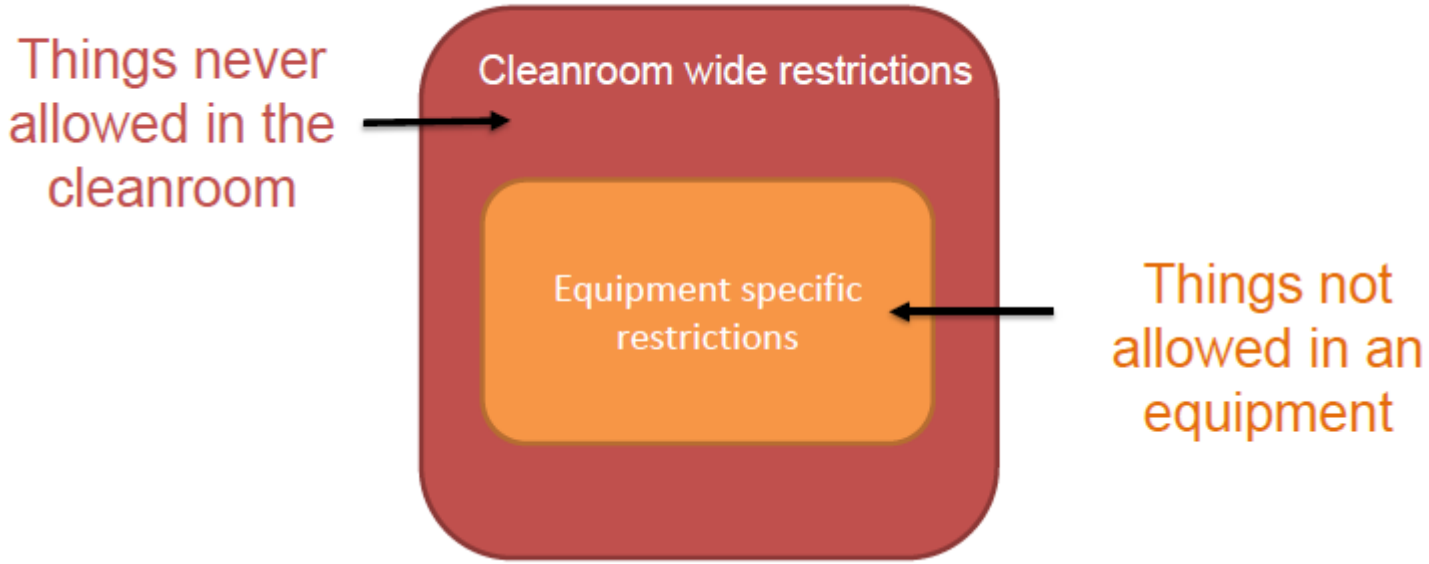
Contamination policy and General rules

Problem of Cross Contamination

- **Definition:**
  - Transfer of undesirable materials from one equipment to another.
- **Occurs because of:**
  - Incompatible process flows : Move from cleanest step to dirty step (downstream). Never upstream.
  - Irresponsible user behaviour : As long as my work gets done, it is not my problem.
- **Causes:**
  - Poor device performance and reliability
  - Poor repeatability of processes
  - Expensive repair/downtime of equipment

What is the Contamination Policy?

Outlines NNFC's policy on allowed/disallowed materials in the cleanroom & each of the equipment



Cleanroom-wide Restrictions

- **Sulfur**
  - Clogs the pumps and valves.

- **PDMS**
  –Please use PV-lab and polymer lab for processing these.

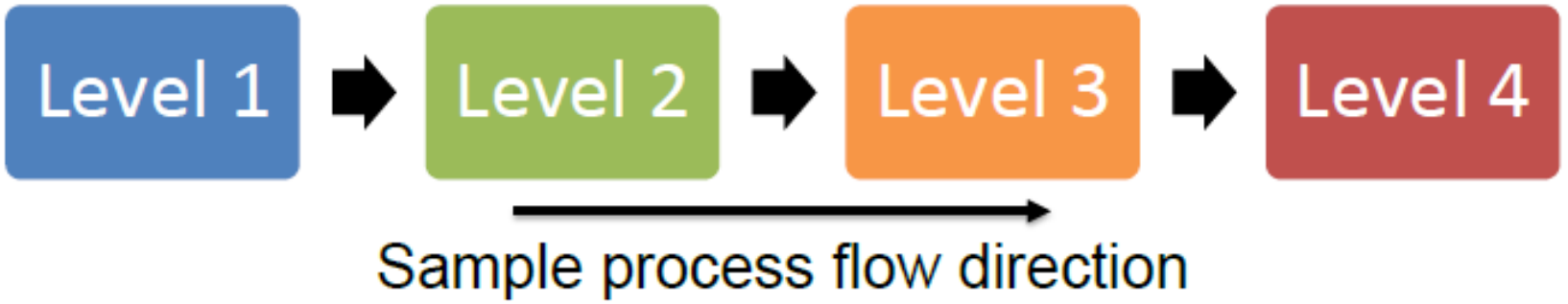
- **Fast diffusing (Cu, Zn, Fe, Mn, etc.), toxic metals (Cd, Sb, Se, As, Hg, etc.), their alloys**
  –Entry allowed only on a case-by-case basis

- **Only approved photoresists allowed in Lithographybay**
  –Standard list available at FOM (purchase supplies)

- **Only approved chemicals allowed at the wet bench**
  –List available at FOM(purchase supplies)

Equipment-Specific Restrictions

- Each equipment has a contamination level
- Based on the contamination level, entry of materials and samples are restricted.
- Basic idea
  - Sample move from low-contamination to high-contamination



Classification of Equipment (Levels)

LEVEL 1 (Color code: Light blue)	• New diced samples/wafer-pieces • Samples from Level 1 equipment • Samples after RCA clean on Level 2 wet-bench • No samples with metals	RCA clean in level 1 wet bench
LEVEL 2 (Color code: Green)	• Samples processed in level 2 • Samples from lithography • No samples with metals	Metal etch in level 3a + RCA clean in level 2 wet bench
LEVEL 3a (Color code: White in orange)	• Samples processed in Level 3 deposition equipment only • Samples with metal allowed but no exposed metal and no fast-diffusing metals.	
LEVEL 3 (Colour code: Orange)	• Samples with any metal • Fast-diffusion metals cannot be exposed and can only be processed at room temperature	Not allowed
LEVEL4 (Color code: Red)	• Samples processed outside NNfC (PV Lab, etc.) • Sample with unknown lineage.	

- **Please note that samples processed in Level 3 will not be accepted in level 2 or 1**

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

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 :

Thank You