

A photograph of a cleanroom hallway with white walls, a blue floor, and yellow safety lines. The hallway is long and brightly lit, with various pieces of equipment and doors visible along the walls.

NNFC Protocols and Policies

**National Nano Fabrication Centre(NNFC)
Centre for Nanoscience and Engineering(CeNSE)
Indian Institute of science(IISc)
Bangalore-12**

Contents



- Introduction – Cleanroom, CR training
- Clean room Protocols
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- Contamination in CR
- PPE and Gowning
- Procedure for withdrawal of Materials
- Equipment Training
- Contamination Policy
- Fire Escape Route Plan-NNFC
- Policy for bringing gadgets or accessories

Cleanroom safety and Protocol Document



- **What is a clean room?**

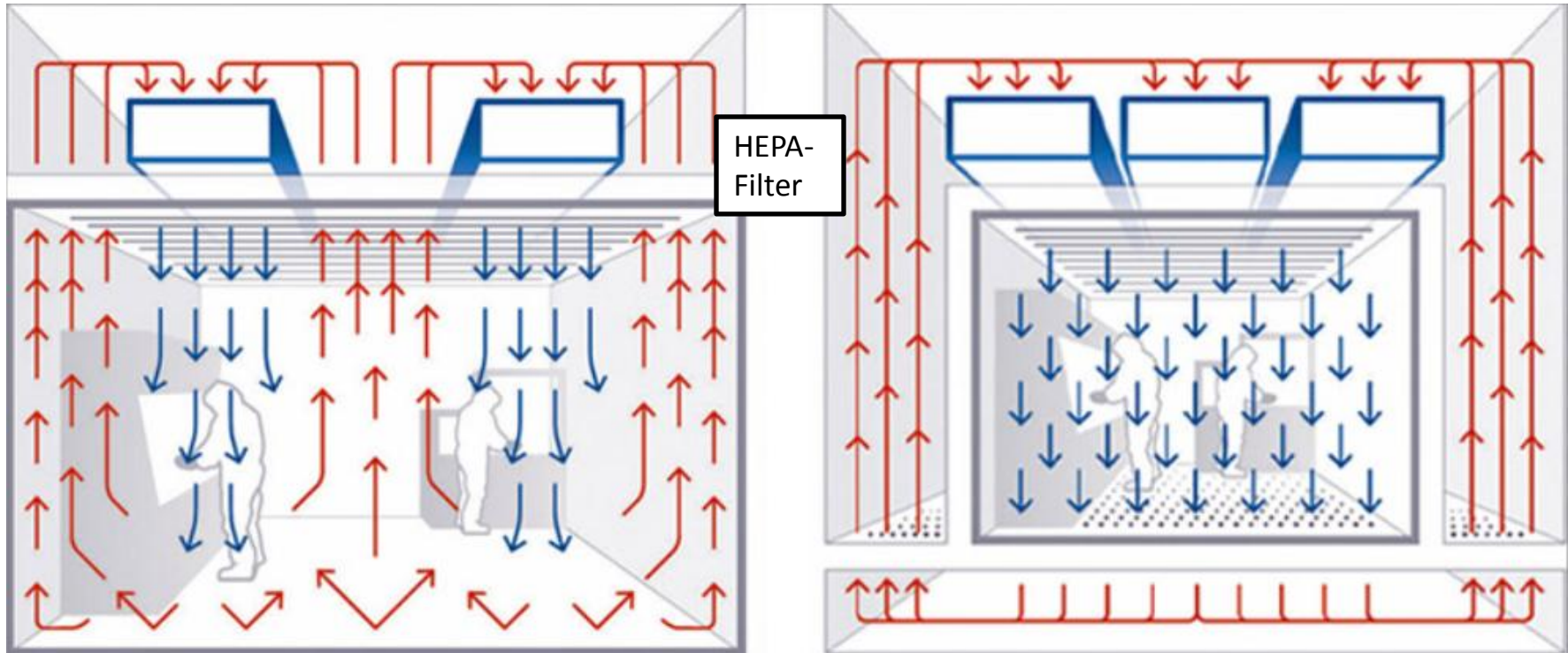
As per ISO standard-14644-1:2015

“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*

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.

 - Wet benches are unavailable everyday from 2 A.M. to 6 A.M.

- **Access- follow the below steps..!!**

1. *Download the authorization form NNFC website*

2. *Fill, sign and submit the same to NNFC office*

3. *Read clean room protocols and safety documents.*

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

5. *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.**
 - Guests are allowed only along the corridor. 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 .
- 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.
- Please make sure that long or medium length hair is tied back.-open hair entry is restricted



“Contact lenses are strictly prohibited”



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 spaghetti 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

❌ People with pacemakers, sleeve less dress and shorts



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**



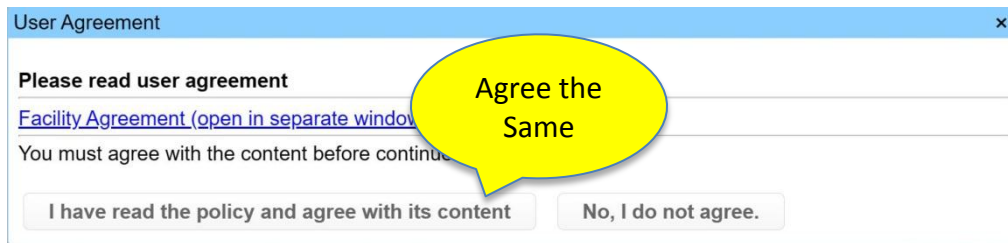
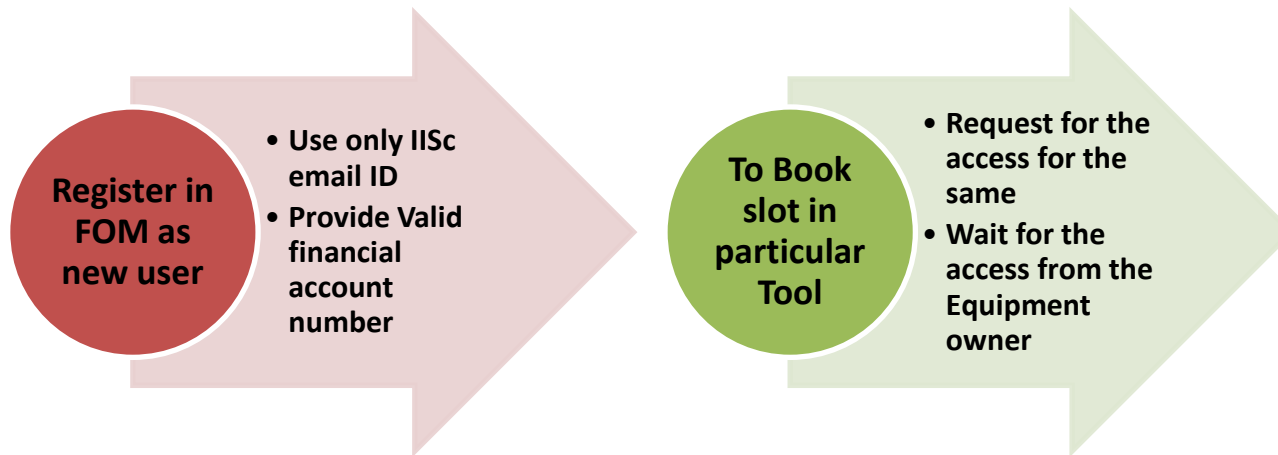
EQUIPMENT USE- General Instructions



- 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



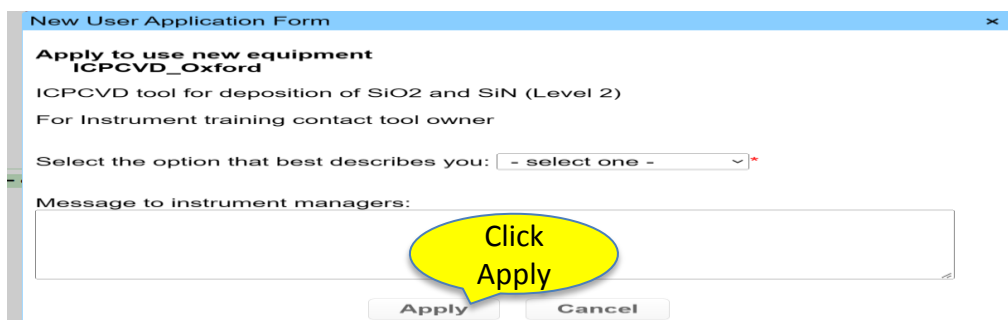
User Agreement

Please read user agreement

[Facility Agreement \(open in separate window\)](#)

You must agree with the content before continuing.

Agree the Same



New User Application Form

Apply to use new equipment
ICPCVD_Oxford

ICPCVD tool for deposition of SiO₂ and SiN (Level 2)
For Instrument training contact tool owner

Select the option that best describes you:

Message to instrument managers:

Click Apply

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 be 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

A screenshot of a web-based reservation form for an "Ellipsometer_JA Woollam". The form is titled "New reservation" and includes the following fields: "Resource" (Ellipsometer_JA Woollam), "Reservation purpose" (My own research), "User" (Shruti Hegde, shrutihegde@isc.ac.in), "Fee structure" (Internal/Startup), "Access Level" (Instrument manager), "Financial account" (Facility Technologist-00), "Reservation" (1/11 11:00 - 1/11 11:30), "Estimated cost" (150), "Additional users" (empty), "Repeat" (None until 01/11/2023), and "Usage Comment" (Thickness Measurement ALD Grown Al2O3/ 2-samples 1cm*1cm/Post Process-Wet Etching at L3 acid bench). The "Reservation" and "Usage Comment" fields are circled in black. The form has "Reserve" and "Close" buttons at the bottom right.

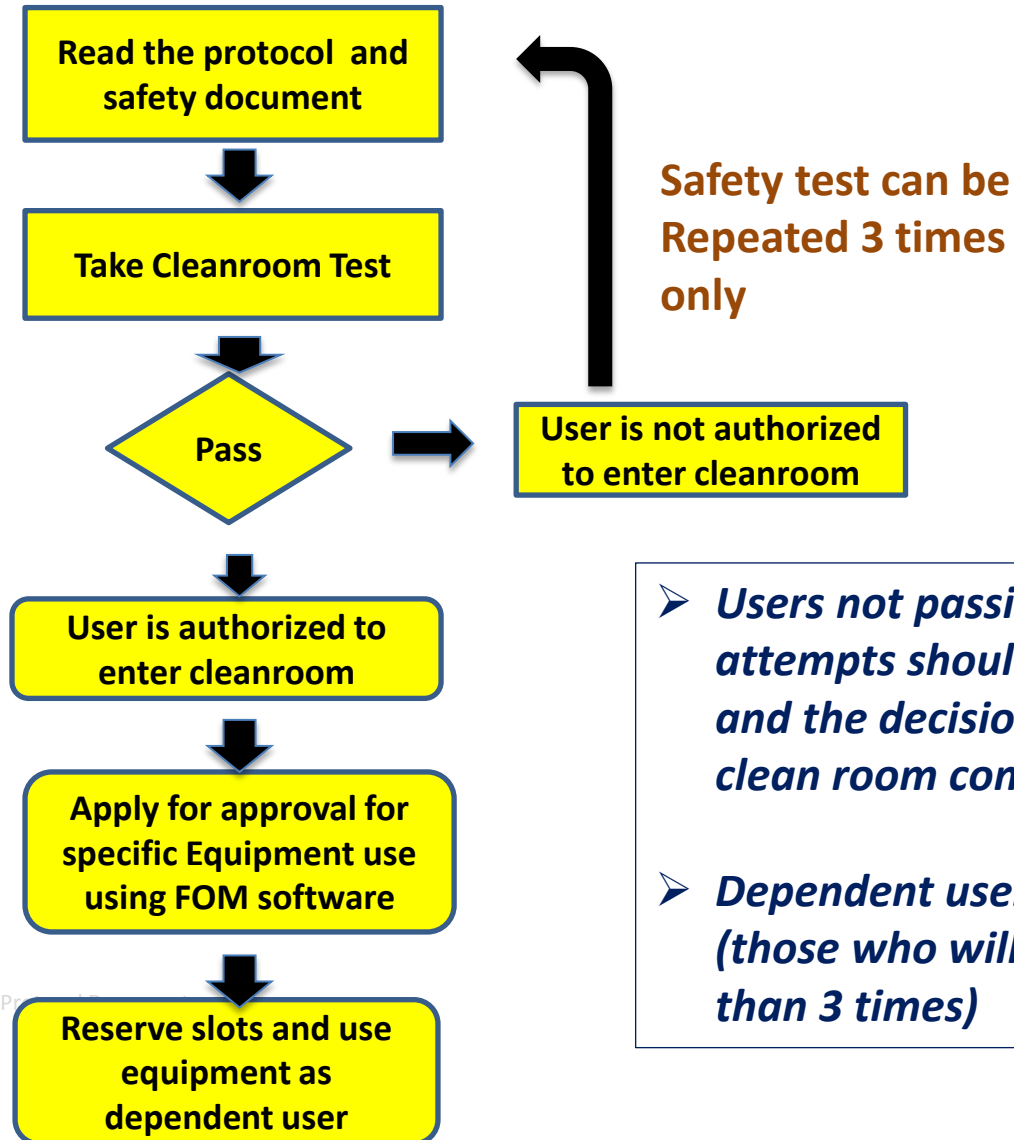
EQUIPMENT USE- Slot cancellation on FOM



- Slots booked by *dependent* users using *express logon* on FOM will not be honored
- Slots booked by *dependent* users *after office hours*
- Slots booked without relevant information, Process conditions, Materials information (different layers, pre and post process).
- Slots booked by users who are under suspension from the cleanroom
- More than 50% 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
- Slots canceled outside of allotted hours and “No show” will

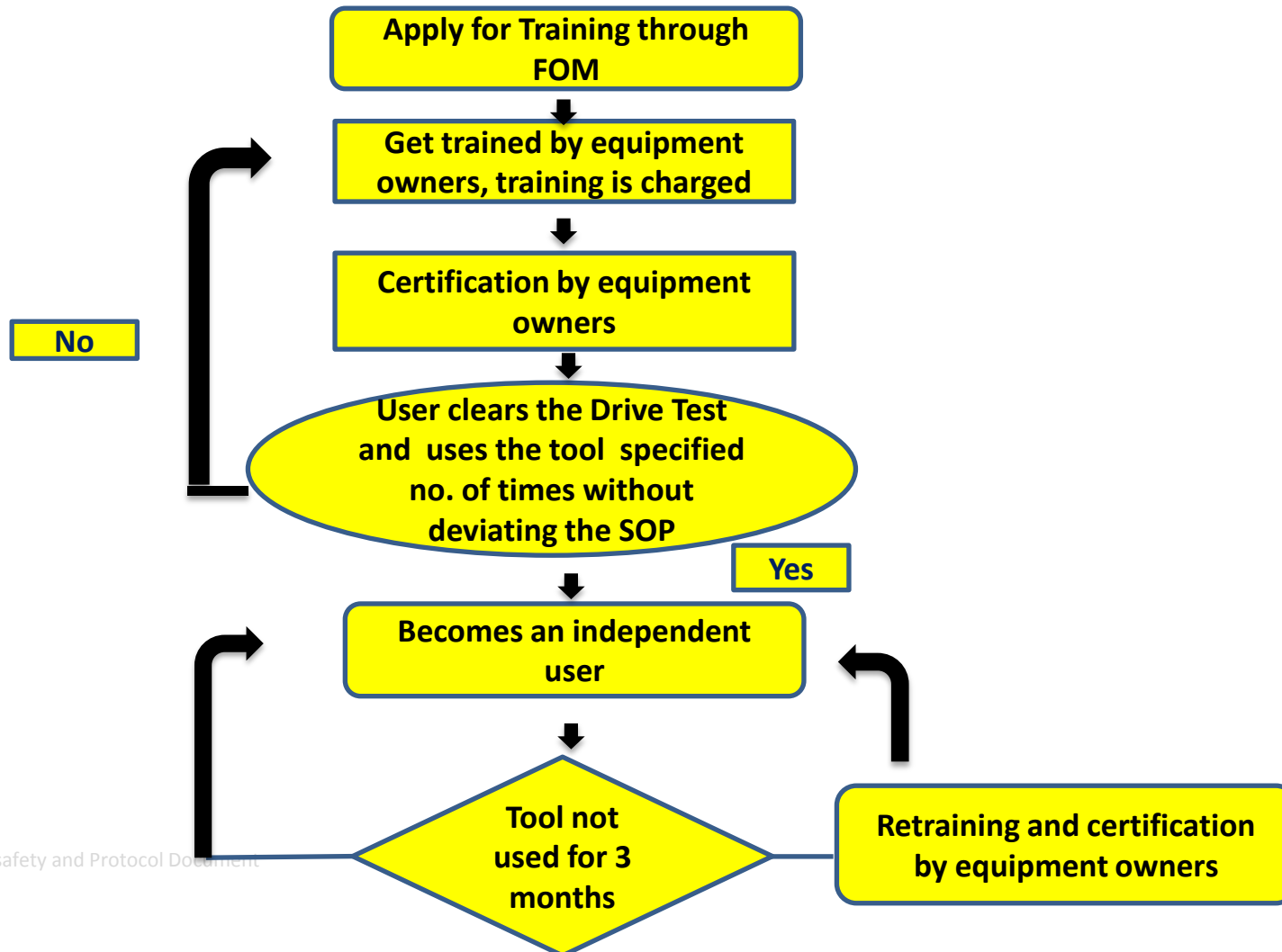


EQUIPMENT USE- How to Become An Authorized User



- *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-aded-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

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 directly walk in for Training slots.

Training slot schedule is as below

	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)
 - Call from outside the fab incase of network problem.
 - Stop the process by pressing the EMO on the Tool.
 - If it is a safety issue immediately inform BMS.
- 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.

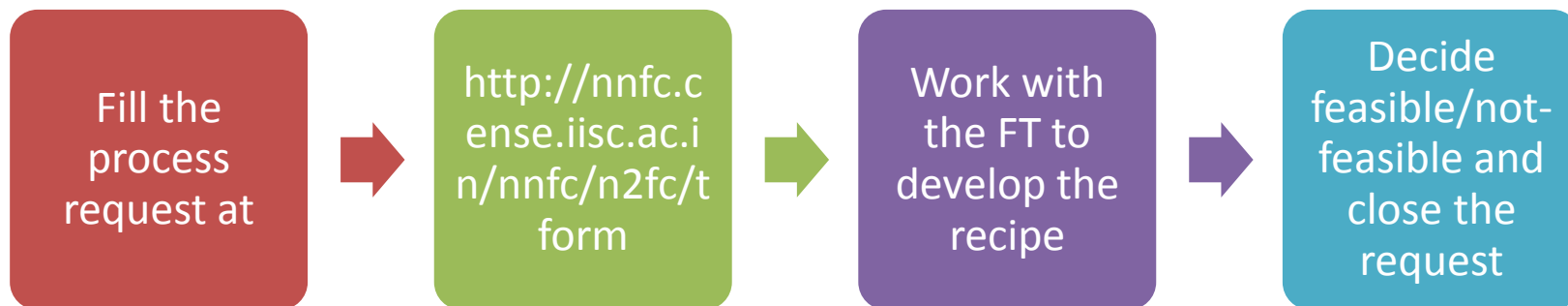


Cleanroom safety and Protocol Document

- **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.

-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



1. Molecular contaminants
2. Surface contaminants
3. 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 (perfumes and sweat)

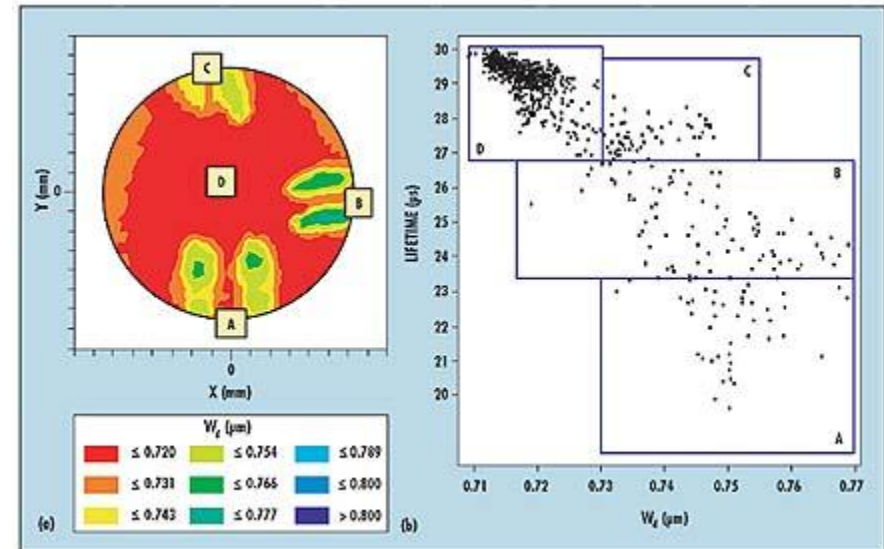
AMC contamination can ruin,

- Devices and circuits
- Production yield.
- Process reliability



Sources of surface contamination

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



Particulate contamination can ruin,

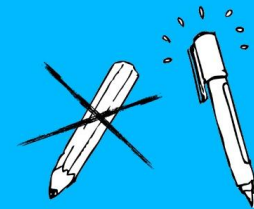
- Devices and circuits
- Device and equipment controllability.
- Process reliability

<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

Tip #1: use a pen, not a pencil



CamCreative April 2013

@francisrowland

Tuesday, 26 April 2013



Cleanroo

Particulate contamination can ruin,

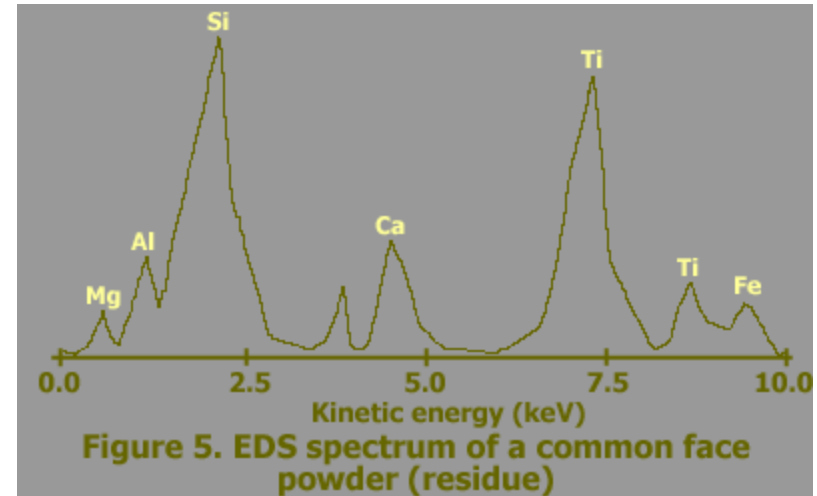
- Device failure-short circuits, pin wholes, open circuits etc;
- Reduce the yield-failed device, many tool hours, fab money
- Mask

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



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

Cleanroom safety and Protocol Document

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

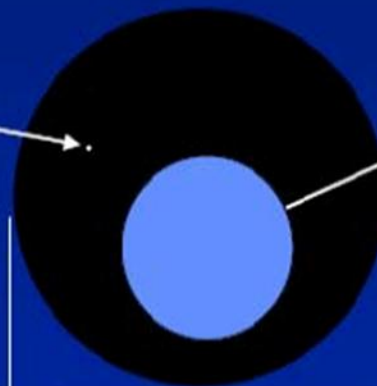


RELATIVE PARTICLE SIZES

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

**SIZE PARTICLE
COUNTED IN
CLEAN ROOMS.
(0.5 MICRONS)**

**SMALLEST SIZE
VISIBLE TO EYE.
(50 MICRONS)**



**HUMAN HAIR
(100 MICRONS)**

**MEASURED
PARTICLES ARE 100
TIMES SMALLER
THAN SEEN BY THE
UNAIDED EYE**

Contamination Sources

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



You are the Primary Contaminant!



100 000



500 000



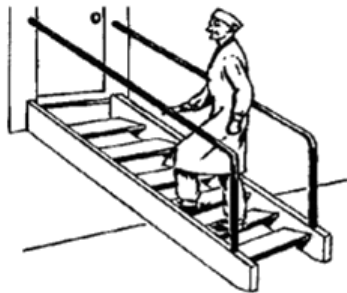
1 000 000



2 500 000



5 000 000 - 10 000 000



10 000 000



15 000 000- 30 000 000

[particles/min $>0,3\mu\text{m}$]

SIZE DISTRIBUTION of PARTICLES from SNEEZES or COUGHS

<u>DIAMETER</u>	<u>SNEEZE</u>	<u>COUGH</u>
• <1-1 μM	800,000	66,000
• 1-2 μM	686,000	21,000
• 2-4 μM	280,000	1,600
• 4-8 μM	134,000	1,290
• 8-16 μM	36,000	490
• +22 μM	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 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.**

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

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)

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**



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, for starts ups under TBI/I2n gmail is allowed
- 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”



Violation of Rules

- Depending on the gravity of violation
 - You *may* get just a warning
 - You may get your booking cancelled
 - You may lose your registration for a short whileOr
You may lose your clean room registration all together!



Cleanroom

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/>



National Nanofabrication Centre



About NNFC ▾

People

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Industry Interaction ▾

Health & Safety ▾

Research ▾

NNFC Resources ▾



HEALTH & SAFETY / SAFETY IN THE CLEANROOM

Safety in the Cleanroom

Contamination Protocol

SAFETY IN THE CLEANROOM

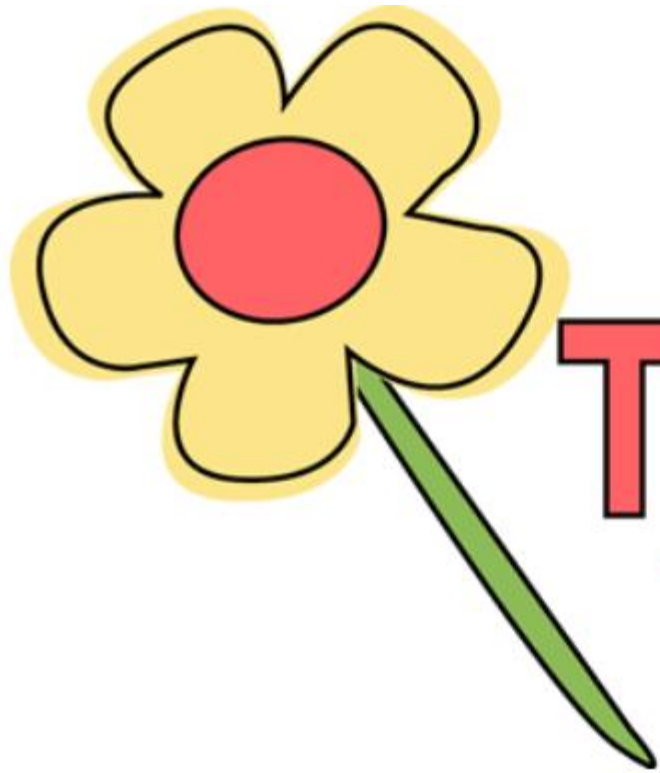
Following cleanroom and safety protocol in the cleanroom is essential for both user and fellow users of the facility. All the users are bound to follow the rules and regulations without any reservation.

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