Safety and behaviour in the cleanroom
Safety and behaviour in the cleanroom

- What is a cleanroom?
- CMi cleanroom concept
- CMi User Manual
- Working in CMi cleanroom
- Safety at CMi
- Visit of the cleanroom
CMi video clip

Video credits: EPFL CMi
What is a cleanroom?
What is a cleanroom?

- Continuous air supply through filters. Laminar flow top to bottom.
- Tight control of working conditions (temp, humidity, UV-light).

**FRESH AIR**
- 60’000 m$^3$/h
- Filter efficiency: 99.97% for particles size: 0.1-0.3 µm

**EXHAUST**
- 36 ’000 m$^3$/h

**FFU**
- 0.7 m$^2$ active area
- Filter efficiency: 99.999% for particles size 0.1-0.3 µm
What is a cleanroom?

- Continuous air supply through filters. Laminar flow top to bottom.
- Tight control of working conditions (temp, humidity, UV-light)
What is a cleanroom?

- Continuous air supply through filters. Laminar flow top to bottom.
- Tight control of working conditions (temp, humidity, UV-light)
What is a cleanroom?

- Tight control of media:
  - Water (minerals, particles, dissolved ions)
  - Chemicals (purity, mobile ions)
  - Gas (purity, water vapor content, particulates)
What is a cleanroom?

Concentration max allowed of particles (particles/m³ of air)
Particles sizes equal or superior to that given below

<table>
<thead>
<tr>
<th>Class ISO</th>
<th>0.1 µm</th>
<th>0.2 µm</th>
<th>0.3 µm</th>
<th>0.5 µm</th>
<th>1 µm</th>
<th>5 µm</th>
<th>Class US FS209</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 1</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ISO 2</td>
<td>100</td>
<td>24</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ISO 3</td>
<td>1 000</td>
<td>237</td>
<td>102</td>
<td>35</td>
<td>8</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>ISO 4</td>
<td>10 000</td>
<td>2 370</td>
<td>1 020</td>
<td>352</td>
<td>83</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>ISO 5</td>
<td>100 000</td>
<td>23 700</td>
<td>10 200</td>
<td>3 520</td>
<td>832</td>
<td>29</td>
<td>100</td>
</tr>
<tr>
<td>ISO 6</td>
<td>1 000 000</td>
<td>237 000</td>
<td>102 000</td>
<td>35 200</td>
<td>8 320</td>
<td>293</td>
<td>1 000</td>
</tr>
<tr>
<td>ISO 7</td>
<td>∞</td>
<td>∞</td>
<td>∞</td>
<td>352 000</td>
<td>83 200</td>
<td>2 930</td>
<td>10 000</td>
</tr>
<tr>
<td>ISO 8</td>
<td>∞</td>
<td>∞</td>
<td>∞</td>
<td>3 520 000</td>
<td>832 000</td>
<td>29 300</td>
<td>100 000</td>
</tr>
<tr>
<td>ISO 9</td>
<td>∞</td>
<td>∞</td>
<td>∞</td>
<td>35 200 000</td>
<td>8 320 000</td>
<td>293 000</td>
<td></td>
</tr>
</tbody>
</table>

Standard ISO 14644-1
What is a cleanroom?

Cleanroom environment requires special cloth, compatible tools, lint free paper.

- Body may contaminate by:
  - Flakes of dead skin
  - Hair
  - Touch by hand
  - Breathing

- Wrong cloth may release:
  - Fibers
  - Dust

- Wrong tools may create:
  - Particles
  - Dust
CMi cleanroom concept
CMi cleanroom concept

CMi BM +1
- Non conventional processes
- Easier access
- Wafers, chips and piece parts
- ISO 6 and 7

Grinding
Thermal imprint
IBE
PDMS line
Photolithography on chips
Customized chemistry
Metrology

CMi BM -1
- 100 mm wafers
- ISO 5
- MEMS cleanroom processes

Ebeam lithography
DUV lithography
Photolithography
Etching plasma and wet
Thins films (LPCVD, oxidation, CVD, ALD)
Metrology
CMi cleanroom concept

Entrance
Changing room
Clean room 370 m² ISO 5 / Class 100
Clean room 280 m² ISO 6 / Class 1000
Clean room 150 m² ISO 7 / Class 10000
Technical area 509 m² ISO 7 / Class 10000
CMi cleanroom concept

CMi - Staff
September 2020
CMi user manual: step by step

1. Safety and behaviour in the cleanroom (now)
   - Formal presentation of CMi facilities and CMi rules
   - Cleanroom visit
   - Email from CMi secretary (process flow template)

2. Project approval by CMi management (~1 week)
   - You send a process flow or a draft to infocmi@epfl.ch
   - Process flow review by a technical committee
   - Email from CMi secretary (username, password)

3. Start working in the cleanroom (few weeks)
   - Trainings
   - Rights to book equipment
   - Work on your own according to process flow (reservation, login, processing, logout...)

CMi user manual: step by step
Process flow work
1. Process flow template
2. User’s modification
3. Process flow sent to CMi
4. Technical committee if necessary
5. Process flow correction
6. Process flow final review by CMi
7. Process flow accepted
CMi user manual: practical training

Training on equipment
- Usually one person at a time
- On your wafers in process (no dummies)
- On the agreed technology
- Limited to the necessary equipment agreed
- Justified only for long term projects
- Planned according to staff availability
- Use training request program

Users feedback to CMi staff
- Modify or adjust technology when problem occurs
- CMi memory
- Improve CMi offer
CMi user manual

CMi web site
https://cmi.epfl.ch/

+ fees
+ training request
+ mailing
+ covid rules
CMi user manual: working hours & staff support

In CMi BM -1 (Z1-Z6), Z14 (chemical lab) and KOH (Z19)
- Open from Monday to Friday from 7am to 7pm
- Staff support until 5pm
- Work prohibited after 7pm

CMi BM +1, Z7 (ebeam lithography), Z8 (FIB), Z9 (dicing), Z10 (parylene, special evap), Z18-19 (CMP, plating, PLD, laser ablation)
- Open 24h/7 days on request
- Staff support from Monday to Friday 7am to 5pm

CMi BM+1, Z7, Z8, Z18-19, device for night access (7pm to 7am) and WE
CMi user manual: fees

Academics
(Practical training, Semester & Master students, PhD students and Researchers)

Tools are charged per run and usage time, Hourly rate depends on tools (see table), Materials and consumables are charged. Manual tools: resists, metals and PDMS charged separately.

Companies

Hourly fees (see table).

➢ All rates (machines, reservation fees, consumables) are available on your CMi user account.

<table>
<thead>
<tr>
<th>Categories</th>
<th>EPFL CHF/run</th>
<th>EPFL CHF/hour</th>
<th>Swiss Academics CHF/run</th>
<th>Swiss Academics CHF/hour</th>
<th>International Acad. CHF/run</th>
<th>International Acad. CHF/hour</th>
<th>Industry CHF/run</th>
<th>Industry CHF/hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Beam Writer &amp; DUV Stepper</td>
<td>35.00</td>
<td>51.00</td>
<td>42.00</td>
<td>61.00</td>
<td>56.00</td>
<td>82.00</td>
<td>113.00</td>
<td>120.00</td>
</tr>
<tr>
<td>Packaging</td>
<td>35.00</td>
<td>62.00</td>
<td>42.00</td>
<td>74.00</td>
<td>56.00</td>
<td>99.00</td>
<td>113.00</td>
<td>105.00</td>
</tr>
<tr>
<td>Laser Writer &amp; Mask Aligner</td>
<td>12.00</td>
<td>32.00</td>
<td>14.00</td>
<td>38.00</td>
<td>19.00</td>
<td>51.00</td>
<td>36.00</td>
<td>67.00</td>
</tr>
<tr>
<td>Coater Developer (Auto)</td>
<td>12.00</td>
<td>100.00</td>
<td>14.00</td>
<td>120.00</td>
<td>19.00</td>
<td>160.00</td>
<td>36.00</td>
<td>177.00</td>
</tr>
<tr>
<td>Coater Developer (Manual)</td>
<td>12.00</td>
<td>37.00</td>
<td>14.00</td>
<td>44.00</td>
<td>19.00</td>
<td>59.00</td>
<td>36.00</td>
<td>59.00</td>
</tr>
<tr>
<td>Dry Etcher</td>
<td>12.00</td>
<td>33.00</td>
<td>14.00</td>
<td>40.00</td>
<td>19.00</td>
<td>53.00</td>
<td>36.00</td>
<td>73.00</td>
</tr>
<tr>
<td>LPCVD, ALD, PVD</td>
<td>12.00</td>
<td>55.00</td>
<td>14.00</td>
<td>66.00</td>
<td>19.00</td>
<td>88.00</td>
<td>36.00</td>
<td>121.00</td>
</tr>
<tr>
<td>Thermal Process</td>
<td>12.00</td>
<td>29.00</td>
<td>14.00</td>
<td>35.00</td>
<td>19.00</td>
<td>46.00</td>
<td>36.00</td>
<td>46.00</td>
</tr>
<tr>
<td>Wet bench</td>
<td>12.00</td>
<td>45.00</td>
<td>14.00</td>
<td>54.00</td>
<td>19.00</td>
<td>72.00</td>
<td>36.00</td>
<td>72.00</td>
</tr>
<tr>
<td>Measurement tools</td>
<td>12.00</td>
<td>18.00</td>
<td>14.00</td>
<td>22.00</td>
<td>19.00</td>
<td>29.00</td>
<td>36.00</td>
<td>45.00</td>
</tr>
<tr>
<td>Other Tools</td>
<td>4.00</td>
<td>12.00</td>
<td>5.00</td>
<td>14.00</td>
<td>6.00</td>
<td>19.00</td>
<td>13.00</td>
<td>24.00</td>
</tr>
</tbody>
</table>
Problem on a processing equipment

General rules:

After each process step the user checks that he got the desired result for their samples. Before starting a new process step, the user takes all possible safeguards (e.g. checking results of previous step, consulting SPC results if available, testing the equipment with a test sample, etc.). Despite the current precautions in place (preventive maintenance, SPC, calibrations and alignments, daily checks, trainings), the machine fabrication capability can be degraded by an inappropriate usage from previous users. Any user who detects a problem must immediately report it to the staff so that the equipment can rapidly be checked by the person in charge. Any complaint about an invoice, concerning or not defective process or equipment, must be addressed to CMi within 24h (one business day). CMi may refund the cost concerning a process step, but will not refund the cost of all proceeding process steps, nor the cost of lost samples. Users are asked to regularly check their current month’s invoice, and to address to CMi any request for corrections before the billing at the end of the month. Once the final invoice is issued, no request for refund can be treated and no modifications are possible.

What to do in case of problem on a processing equipment:

1. The user immediately reports to CMi staff so the concerned equipment can be checked and preventively put to maintenance state.
2. The user sends an email to the staff member in charge the same day with:
   a. User login
   b. Machine
   c. Date
   d. Time
   e. Related process flow document mentioning the concerned process step
   f. If possible, a picture of the sample
   g. The requested adjustment of the invoice
3. The user transmits the sample to the staff in charge for inspection.
4. If applicable, the user checks the ongoing invoice that agreed refund is effective, before the billing at the end of the month.
Cleanroom general rules

- Material should be stored in labelled basket
- All wafers should be in boxes with:
  - Labelled owner and date
  - Ideally with process flow in snap-on clear envelopes

- Lost and found shelf

- Wafers/samples must be handled with vacuum or mechanical tweezers
Entering CMi cleanroom
Accesses, main delivery place and material introduction into cleanroom
Enter only through entrance specified in your authorization email. Exit only through the same entrance you used for entry.

**CMI ENTRY procedure**

IF YOU HAVE ANY SYMPTOMS OF FLU DO NOT ENTER CLEANROOM !!!

1. Desinfect your hands !

2. Put on new clean white face mask.

3. Put on the gloves.

If you need to store smtg in the locker, wrap it in the plastic bag.

4. Put on blue shoe cover and pass the bench.

5. Put on hair net.

6. Put on your private suit from your sack.

7. Put on boots. Boots are shared.

8. Put on your personal safety or medical glasses.

9. Check everything again. You should look like this. Enter the cleanroom.

ANYTIME YOU CHANGE GLOVES WASH YOUR HANDS!!!
CMI EXIT procedure

1. Remove boots and put them back on the shared shoe shelf.

2. Remove your suit and place it and your glasses in your sack.

3. Remove hair net and trash it.

4. Cross over the bench and trash the blue shoe covers.

5. Pick your stuff from the locker, if you used it.

6. Exit cleanroom.

7. Trash your gloves!

8. Keep your face mask or put on your private one.

ANYTIME YOU CHANGE GLOVES WASH YOUR HANDS!!!
Material introduction into cleanroom

- All the material introduced in CMi cleanroom:
  
  • Must be announced to infocmi@epfl.ch for the first time
  • Must be decontaminated:
    • in dedicated material room for BM -1
    • in dressing room for BM +1 and FIB room

- Outside the cleanroom: decontamination

1. Put on gloves.
2. Wipe with IPA.
3. Place inside the cabinet, on appropriate shelf.
4. Get dressed to access the cleanroom.
5. Collection from inside the cleanroom.

Operate the other way around to get the material out.
Mobile phone policy

No phones in processing area!

You may:

▪ Use an earpiece headset, (only 1 allowed, no listening to music in cleanroom!)
▪ Or go in the dressing room (best solution),
▪ Or go to grey area (acceptable solution).

Remark: staff may use mobile phones in the processing area for alarms and repairing/diagnosing tools. Not a privilege but an exception!
Safety at CMi
Mandatory course for CMi Users

"Management of chemical hazards and risks“

Objectives of the course are:

- Reminder on basics in chemistry
- Recognising and managing some specific hazards and risks
- Utility and essential points of the Safety Data Sheets (SDS)
- Preventing events/ knowing how to choose safety equipment
- Storing chemicals and waste safely

Next courses:  
Tuesday 22\textsuperscript{nd} September from 09:00 to 12:00, place: ME B3 31  
Tuesday 20\textsuperscript{th} October from 09:00 to 12:00, place: ME B3 31  
Tuesday 15\textsuperscript{th} December from 09:00 to 12:00, place: to be defined

You will receive an invitation
Safety rules: general

CAMIPRO required for each person entering or leaving the cleanroom
Never work alone: a buddy is required in the cleanroom at all times
Only one emergency phone number:

115

Report any safety problems you encounter
Wear protective glasses or medical glasses all the time
Safety rules: alarms & Evacuation in CMi BM -1 / Z18-19

Double tone horn
Flashing red light
➔ Evacuate immediately with cleanroom clothing

Meeting point: BM 1.124 (CMi secretariat office)
wait there to be accounted for

Remark: red alarm can be activated by the push-buttons
Safety rules: chemicals and trash

NO CHEMICALS in personal lockers or in personal storing baskets!!!

Dedicated bins for Silicon wafers and other glass parts
NEVER trash sharp objects in regular bin with plastic bag
Safety rules: chemistry

- INFORM yourself (SDS).

- Do NOT crowd fume hoods/wet benches!

- Only ONE user at a time for “strong” chemistry (concentrated acids/bases).

- Do NOT stress operator for quick finish.

- Finish clean and safe (workplace, bottles, wares...)

Extra dressing
- nitrile gloves
- safety apron
- face shield
- long gloves
1. Standard Operation Procedure

1.1 Procedure name and description

SOP name: TMCS anti-dicing

This product is mainly used in PDMS casting processes as a surface conditioning treatment to prevent sticking between piece parts which come into contact for molding purposes but which need, in the end, to be easily separated from each other. Proceed on the dedicated wet bench as out line below.

- Put on single use additional gloves.
- Fetch the TMCS bottle in the “solvent” cabinet located on the right side of the wet bench.
- Place 2 or 3 drops of TMCS in the small glass receptacle located in the glass desiccator (single use pipettes are available for that purpose).
- Place the silicon/SU8 mold in this very same desiccator.
- Close the desiccator and place it under vacuum (this causes the TMCS to evaporate and to form a passivation layer on the mold surface).
- Close the TMCS bottle and put it back in the “solvent” cabinet. Fill-in the "chemicals follow-up" document.
- When desired time is reached, vent the desiccator once. **DO NOT** open it yet. Put it back under vacuum for a while so all TMCS vapors are sucked away.
- Vent it and open it. **DO NOT** breath directly above the open desiccator.
- Take your mold back and close the desiccator.

1.2 Working hours restrictions

Allowed under "strict buddy rule". A buddy may be any authorized user of the clean room in visual contact with the authorized user. Strictly apply personal protective behavior of point 2.4.

2. Safety

2.1 Material Safety Data Sheet: see concerned document

2.2 Hazards associated to the chemical (choose according to MSDS)

2.3 Risk and Safety phrases

- R11 Easily flammable
- R14 Reacts violently to water contact
- R36 Provokes serious burns

2.4 Protective behavior and equipment needed

**Respiratory protection**
Always wear the clean-room facial mask. Do not breathe vapors, gases. Ensure correct ventilation, manipulate under a venting hood.

**Hands protection**
In addition to the standard clean-room gloves, always manipulate using extra-single-use gloves.

**Eyes protection**
Always wear the clean-room safety glasses.
Safety rules: chemistry

Specific CAMIPRO access for:

- **HF** Hydrofluoric Acid
- **HNO₃** Nitric Acid
- **TMAH** Tetramethylammonium Hydroxide
- **Mixtures**

Chemicals use authorization - CMi

This paper must be signed by all cleanroom users working in zone 14 (BM 1.116) with one or more chemicals (included mixtures) mentioned below:

*Please check the appropriate box.*

- **ACID** - Hydrofluoric acid (HF)
  - CAS number: 7664-39-3

- **ACID** - Nitric acid (HNO₃)
  - CAS Number: 7697-37-2

- **BASE** - Tetramethylammonium hydroxide (TMAH)
  - CAS Number: 75-59-2

The signing person hereby confirms to have read the MSDS of these chemicals (available here [https://cmiaccess.epfl.ch/restricted](https://cmiaccess.epfl.ch/restricted)) and understood risks. The user also commits to respect CMi Safety rules and never provide these chemicals to someone else.

When requested, CMi commits to give access to the above-mentioned chemicals stored under lock.

Date

Name user (in block letters please)

Lab / Company

Signature user

Signature CMi staff - Etching Dept
Thank you for your attention.

Now is the moment to ask questions, to share observations and to make comments.