Topic 4 : Cleanroom laboratory

The objective of this cleanroom session is to:

- Familiarize students with the cleanroom environment, equipment, and safety rules.
- Properly handle wafers and masks throughout the fabrication sequence. Wafers must be handled with the appropriate tweezers and great care. Never touch the surface of the wafer, even with gloved hands.
- Perform a wet etching process on an aluminum film.
- Understand proper behavior in the cleanroom.
- Prepare and use a process flow.

In this topic, you will explore the cleanroom environment (CMI-EPFL) and observe the execution of basic microfabrication operations performed by automatic machines. In topics 2 and 3, you carried out similar operations manually in a standard laboratory (DLL-MED). Comparing these two environments will provide valuable insights into why microfabrication requires a cleanroom setting.

As the machines in the cleanroom are complex and expensive. Their use requires training by CMI staff. This is why your TA will carry out most of the process steps. You will be observers, but feel free to be curious and ask questions about the different fabrication steps, the cleanliness of the cleanroom, as well as the differences between the cleanroom on the 1st floor (CMI/+1) and the one on level -1 (CMI/ -1). You can also, observe the differences between handling wafers manually or automatically. The time required to finish the complete process, etc.

Important: During your session, carefully follow the process descriptions and instructions provided by your TA. Take detailed notes on the explanations given, as these will be essential for your final report to describe all the procedures you perform in the cleanroom.

Questions:

Answer the following questions at the end of your session:

- What is the cleanroom class for the level +1 and level -1 areas?
- How many wafers can be coated and developed using the EVG150?
- How long does it take to expose your wafer on the MLA 150-1?
- How long does it take to expose a wafer with the setup in DLL-MED (topics 2 & 3)?
- What is your conclusion when comparing the cleanroom environment to the laboratory environment in DLL? The manual and automatic processing?

1. **Entering the cleanroom**
    - Sit down on the bench.
    - Put on plastic overshoes normally available close to the bench.
    - Get a cleanroom suit to your size. When dressing, make sure that the sleeves do not touch the floor.
    - Put on boots/cleanroom shoes.
    - Put on a cleanroom mask and a hair net.
    - Put on safety goggles (if no medical glasses).
    - Put on gloves.
    - Check if you are well dressed up before entering in the cleanroom.

2. **Aluminium wet etching**.

   For this exercice you need:
    - PR/ Al / SiO_2/Si wafer (1 Wafer)
    - Al / SiO_2/Si wafer (1Wafer)

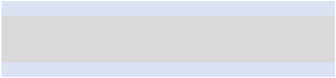
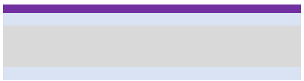
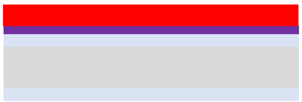
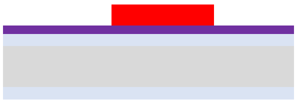
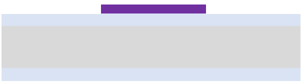
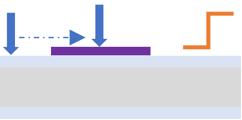
- Your gds file already prepared: this file contains patterns for resistance fabricatiom, and photos you have proposed.
- Wet etching is a cleanroom process used to apply a patterned thin film on the surface of your substrate. Before wet etching, patterns are created on a photoresist mask by performing photolithography directly on the wafer surface. If everything goes as planned, the patterns on your wafer, protected by the photoresist, should remain intact, while the unprotected areas of the film will be etched away by the etching solution. After the wet etching process, the photoresist mask is removed using a solvents or plasma oxygen.

Steps to follow:

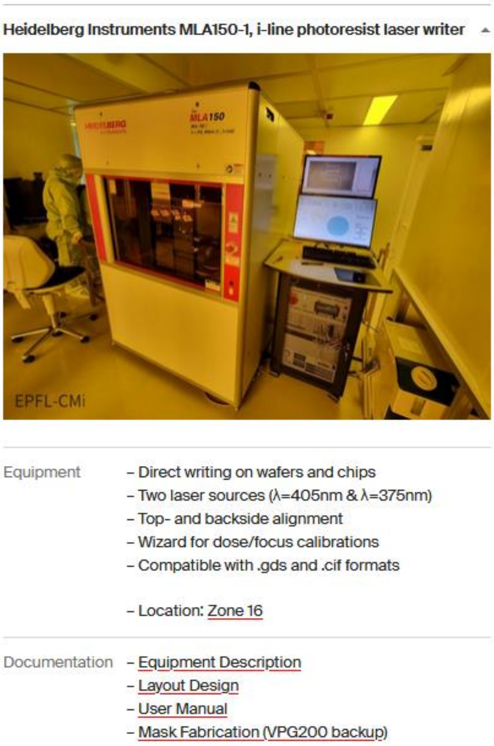
- Follow the steps as indicated in the process flow.
- Steps 1 to 3 have already been completed; you will begin from step 4.
- During development in the EVG 150, you will perform photoresist coating (step 3) on a second wafer, which has only steps 1 and 2 completed. This wafer will be used by the next group.
- In aluminum etching, the areas of the aluminum film not protected by the resist mask are removed in APN, a mixture of three acids: acetic acid, phosphoric acid, and nitric acid. This mixture etches aluminum at approximately 300 nm/min at 35°C and is highly selective to aluminum compared to the photoresist.
- Photoresist stripping, can be done manually, or in plasma oxygen

3. **Aluminum Thickness Measurements**
    - Measure the thickness of the patterned aluminum film with the Stylus Profilometer
4. Store your wafers in their box until the characterization session (topic 5).

The process flow:

Step	Process description	Cross-section after process
01	Substrate: *Si test* *RCAcleaning* Machine: *Plade RCA- Z3* *Wet Oxidation* Machine: *Centrotherm -Z3*	
02	*Metallization* Machine: *Spider 600- Z4* *Couche:AlSi 1%*	
03	*Photolith PR coat* Machine: EVG 150 *Coater Z6* PR : *AZ ECI 3007– 1 µm* Pr: C4_H_3007_1ux (With HMDS)	
04	*Photolith expo+ develop* Machine: MLA 150-1 Z16 EVG 150: *DEVELOPER AZ 726 MIF –Z6*	
05	*Wet Etch* Material : *AlSi 1%* Machine: *Plade Metal Z2* *ANP bath* *Time: (5 to 10 min)*	
06	*Resist Strip* Material: *AZ ECI 3007– 1 µm* (Z2) Bain remover 1165, Or plasma Oxygen, Or Acetone + IPA	
07	*Thickness measurement* *Dek Tak Z15*	

5. **Equipments used**: The user manual and contact information can be found in the provided links.



Heidelberg Instruments MLA150-1, i-line photoresist laser writer

Equipment	– Direct writing on wafers and chips – Two laser sources (λ=405nm & λ=375nm) – Top- and backside alignment – Wizard for dose/focus calibrations – Compatible with .gds and .cif formats – Location: Zone 16
Documentation	– Equipment Description – Layout Design – User Manual – Mask Fabrication (VPG200 backup)

https://www.epfl.ch/research/facilities/cmi/equipment/photolithography/

Automatic coaters & developers

EVG 150, cluster for i-line photoresists

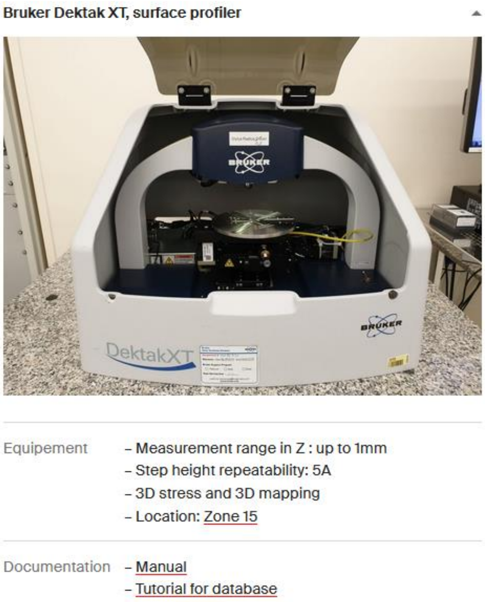
Equipment	– Automatic (batch) spin-coating and development – 100mm and 150mm wafers – Up to 9 photoresist pump dispense lines + 3 N_2 pressure dispense lines – 3 photoresist developer lines (spray or puddle) – HMDS vapor-prime module – Effective mini-environment and temperature control in spin-modules – i-line resists: AZ ECI 3007, AZ 3027, AZ 1512, AZ nLOF 2020, AZ nLOF 2070 – Protection resist: AZ P4K-AP – Lift-off bottom layer: LOR 5A, LOR 15C – Anti-reflection bottom layer (BARC): XHRiC-16 – Developer chemistry: AZ 726 MIF (2.38% TMAH), AZ Developer (aluminum firendly) – Location: Zone 6
Documentation	– Equipment Description – User Manual

https://www.epfl.ch/research/facilities/cmi/equipment/photolithography/

Plade Metal, wet bench, metal etch

Equipment	– 100, 150 mm wafers and piece parts – Aluminium etch – Titanium etch (HF 1%) – Reclaim (HF 50%) – Polysilicon etch – Location: Zone 2
Documentation	– Manual – Safety – Available holders

https://www.epfl.ch/research/facilities/cmi/equipment/etching/



Bruker Dektak XT, surface profiler

Equipement	– Measurement range in Z : up to 1mm – Step height repeatability: 5A – 3D stress and 3D mapping – Location: Zone 15
Documentation	– Manual – Tutorial for database

https://www.epfl.ch/research/facilities/cmi/equipment/metrology/

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



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.

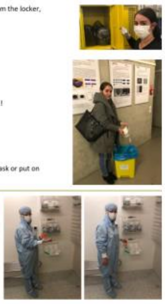
5. Put on hair net.
6. Put on your private suit from your sack.
7. Put on boots. Boots are shared.
8. Put on your personal safety or medical glasses.
9. Check everything again. You should look like this. Enter the cleanroom.

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!!!

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…)

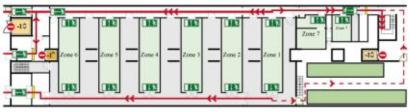
Extra dressing

- nitrile gloves
- safety apron
- face shield
- long gloves

Safety rules: alarms & Evacuation in CMi BM -1 / Z18-19

Double tone horn
Flashing red light
→ Evacuate immediately <u>with cleanroom clothing</u>

Toxic gas
Fire



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: 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 :

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Report any safety problems you encounter
Wear protective glasses or medical glasses all the time

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