Topic 4 : Cleanroom laboratory

The objective of this cleanroom session is:

- to familiarize students with the cleanroom environment, equipment, and safety rules.
- To handle correctly wafers and masks until the end of the fabrication sequence. The wafer must be handled with the appropriate wafer tweezers and with great attention. Never touch the surface of the wafer, even with gloved hands.
- To practice alignment between two levels
- To do a wet etching process of aluminum film
- To prepare a photomask
- To learn the behavior in the cleanroom
- To prepare and use a process flow

Important: During your session, follow the process descriptions and details provided by your TA. You should take notes of the explanation given by your TA to be added in your final report to explain all procedures you have performed in the cleanroom.

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. Photomask fabrication

The photomask is a solid, transparent substrate, such as glass or fused silica, which has an opaque coating on one surface into which a microscopic pattern has been etched, leaving some regions transparent and others opaque. Light can pass through the mask only from the transparent regions. When the photomask is placed in proximity to another substrate coated with photosensitive material called photoresist, only the light that travels through the photomask will irradiate the photoresist.

- Your photomask is created by designing patterns using CAD (Computer Aided Design) tools, such as Klayout (free software), and a gds file is generated.
- Laser writer VPG200 has been used to write this file on the photoresist of the photomask.
- With your TA, you will continue the rest of the process: development of the photoresist, Chrome etch, and resist stripping. Hamatech HMR900 is a tool dedicated to Cr-plate wet processing or cleaning. Three dedicated media are installed for

successive chemical treatment of standard Cr-blanks (developing exposed resist – Cr wet etching – resist striping) with intermediate DI water rinse and final drying. The tool is designed to handle square plates up to 7" x 7" (Cr-blank for mask aligner or reticule for DUV stepper)

3. SiO_2 Film Formation and Mask Alignment

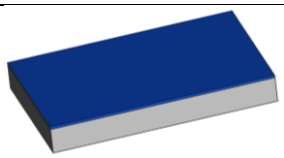
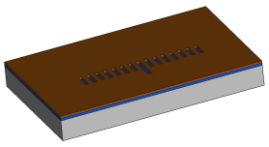
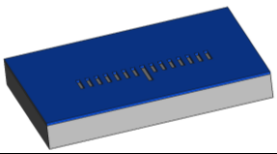
You need:

- PR/ SiO_2/Si wafer
- Mask level 2

A SiO_2 film is formed through the oxidation of a silicon wafer, resulting in a film thickness of 100 nm. This oxidation process can occur in a high-temperature oven, where silicon reacts with oxygen to create a thermal oxide layer

To transfer the initial designs onto the SiO_2 film (a) , mask level 1 is used. This involves applying a photolithographic process where a photoresist is patterned onto the SiO2 layer. The unprotected areas of the film are then selectively removed using a Buffered Oxide Etch (BOE) (c). BOE is a specialized etching solution that typically contains a mixture of ammonium fluoride and hydrofluoric acid, which effectively etches silicon dioxide. The careful control of the etching parameters ensures that the desired features are accurately transferred.

Step	Process description	Cross-section after process
01	**Substrate**: SiO2/***Si test*** Thickness: *0.5 µm*	
02	*Photolith PR coat* Machine: ACS 200 *Coater (Z1)* PR : *AZ ECI 3007– 1 µm* Pr: C4_H_3007_1ux_EC (With HMDS)	
03	*Photolith expo+ develop* Machine: Süss MA6 Gen3 (Z6) ACS 200 (Z1) : DEVELOPER AZ 726 MIF	

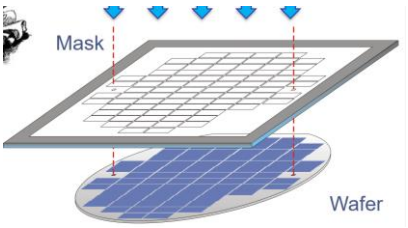
(a)	(b)	(c)
		

Task: Aligning Mask Level 2

Your objective is to align Mask Level 2 with high precision relative to Level 1.

- Preparation: Ensure that the Süss MA6 Gen3 mask aligner machine is set up according to the specifications provided by your Teaching Assistant (TA).
- Start by loading the mask onto the contact aligner mask stage. Turn on the mask vacuum and raise the mask stage.

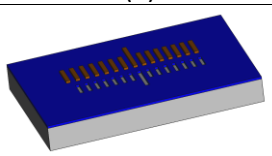
- Loading the wafer on the center of the wafer holder, the photoresist side facing up to the photomask. Turn on the substrate vacuum to fix the substrate in place.
- perform a wedge error compensation (WEC). This step ensures that the sample is parallel to the photomask.
- Align the mask to the wafer using the alignment marks on the sides of the wafer and the mask. The mask aligner has two objectives allowing the user to view both alignment marks simultaneously. The image seen is split in half with the left image corresponding to one location of the substrate and the right half corresponding to another location of the substrate.



- Alignment is achieved by adjusting the x, y, and θ (theta) positions of the wafer in relation to the stationary mask. This process is crucial for ensuring that the patterns on Mask Level 2 accurately overlay those on Mask Level 1.
- After finishing the alignment, expose your wafer to UV light. The exposure time must be previously determined from the datasheet of the used photoresist. During the exposure, make sure you turn away from the UV light to protect yourself from the UV exposure.
- Automatic development step involves a systematic procedure that includes developing the wafer in MIF726 developer, followed by a thorough water rinse, and finally, a nitrogen (N2) drying process.

After the UV exposure and development process, your substrate will consist of three distinct materials: Si Wafer, thin SiO_2 film, and a photoresist layer. The schematic below (e) illustrates a vernier designed for measuring alignment errors. This tool is essential for ensuring that the patterns transferred onto the substrate are accurately aligned, which is critical for the performance of the final device. Understanding these alignment errors will be further explored in Topic 6, where detailed methodologies for measurement and evaluation will be discussed.

(e)



4. **Aluminium Etching**.

For this exercice you need:

- PR/Al/Glass substrate
- Your mask you have prepared

Steps to follow:

- The process flow for this exercise is below

Step	Process description	Cross-section after process
01	**Substrate**: ***Al/Glass*** Thickness: *0.8 µm*	
02	*Photolith PR coat* Machine: ACS 200 *Coater (Z1)* PR : *AZ ECI 3007– 1 µm* Pr: C4_D_3007_1ux_EC (Without HMDS)	
03	*Photolith expo+ develop* Machine: Süss MA6 Gen3 (Z6) ACS 200 (Z1) : DEVELOPER AZ 726 MIF	
04	*Wet Etch* Material : *Al* (Z2) Plade metal : APN depth : *0.8 µm*	
05	*Resist Strip* Material: *AZ ECI 3007– 1 µm* (Z2) Bain remover 1165	

- Load the mask you have prepared with your assistant on the Süss MA6 Gen3 mask aligner. Load the PR/Al/Glass substrate on the machine. No alignment is required. Contact and expose to UV light for the right exposure time.
- The exposure time is determined with your TA and also you take note of the manner of determining this time to be included in your final report.
- Automatic development step involves a systematic procedure that includes developing the wafer in MIF726 developer, followed by a thorough water rinse, and finally, a nitrogen (N2) drying process.
- Aluminum etching, this step should be carried out by the lab TA for safety reasons. The exposed aluminum film is removed in APN a mixture of three acids: Acetic, Phosphoric, and Nitric. It etches aluminum at approximately 300 nm/min and is highly selective to aluminum compared to photoresist.
- Photoresist stripping
    - Can be done manually, or in plasma oxygen

5. **Aluminum Thickness Measurements**

i. Measure the thickness of the patterned aluminum film with the Stylus Profilometer

6. Store your wafers in their containers until the characterization session (topic 6).

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…)

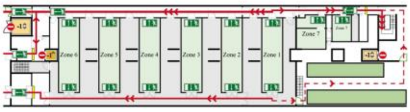
Extra dressing

- 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 :

115

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