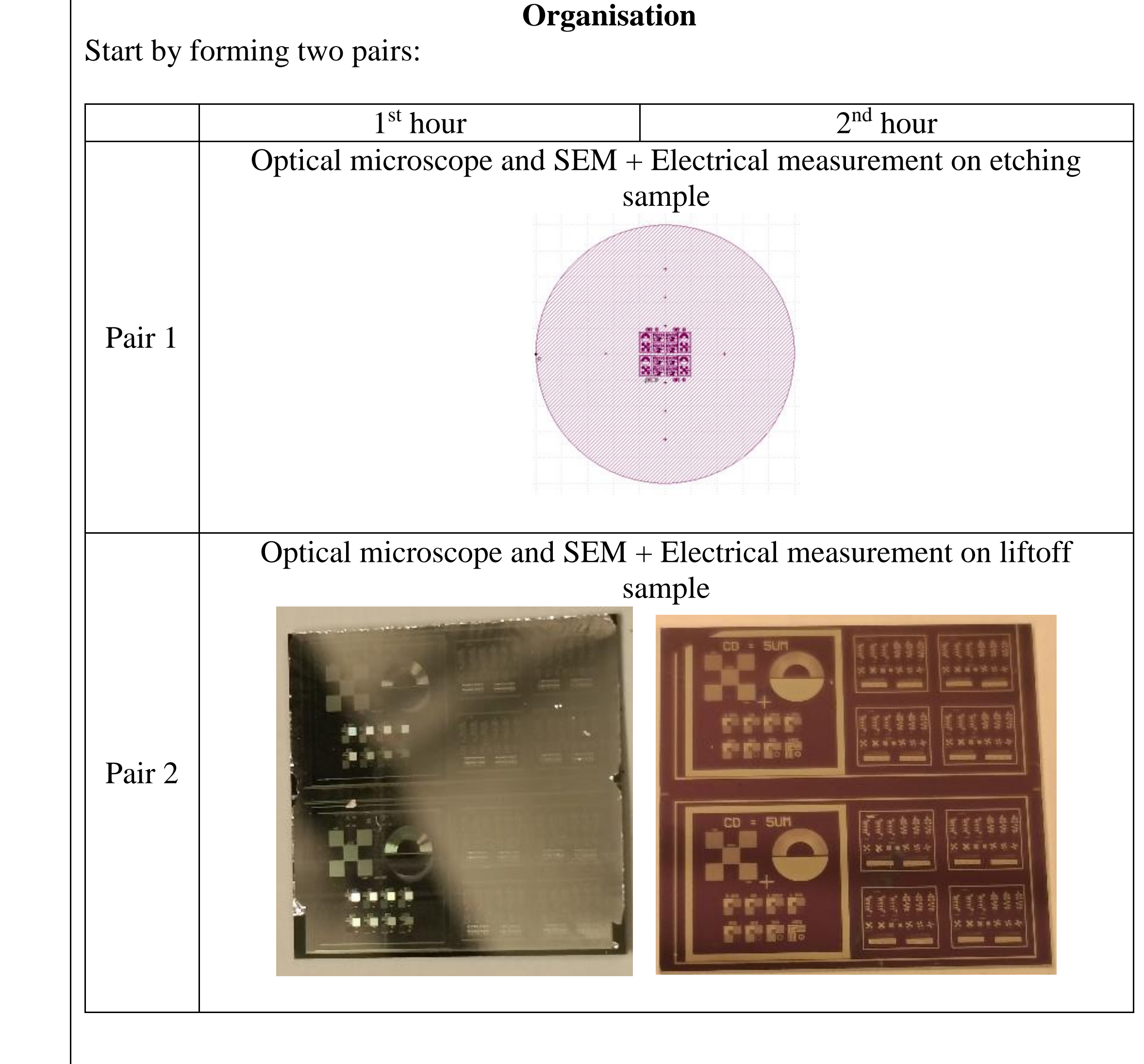
Organisation

Start by forming two pairs:

	1st hour	2nd hour
Pair 1	Optical microscope and SEM + Electrical measurement on etching sample	
Pair 2	Optical microscope and SEM + Electrical measurement on liftoff sample	

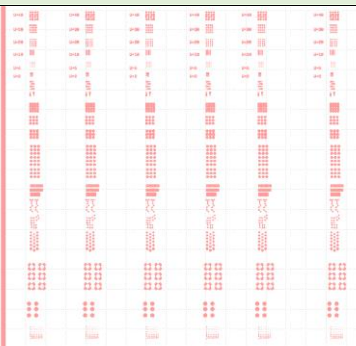


Optical characterisation

Liftoff resist

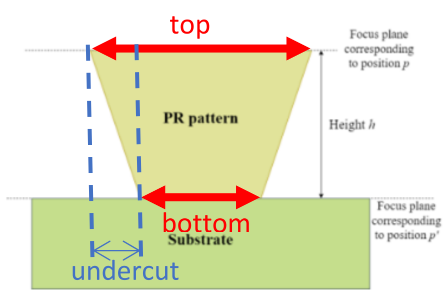
A liftoff process required a consistent undercut in the photoresist. Two different methods are compared. The first method was based on a negative tone resist (nLOF2070). The second method was based on a two-layer positive tone resist AZ 1512 or ECI3027 deposited onto a sacrificial resist layer LOR 15C.
Optical microscope will be used to view each of the prepared samples, while the scanning electron microscope will be used to observe only selected samples.

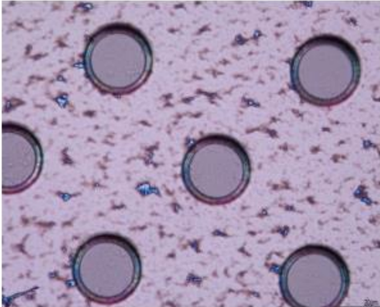
nLOF 2070



The screenshot of the test patterns is shown above. Don't waste time characterizing all of them; instead, select the ones that clearly display the desired undercut phenomenon, characterized by a negative slope of the profile.

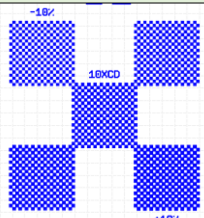
- Measure at the top of the pattern and at the base of the structure as illustrated in the following:





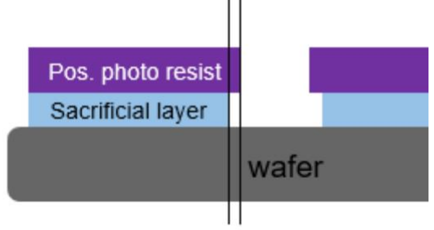
- Calculate the difference between these two values.
- What observations can you make regarding this difference and its relation to the liftoff process?
- From topic 3, what is the thickness of the resist layer?
- Calculate the angle of the negative slope.

Two- layer PR/LOR



For the two-layer resists, use the above test patterns to perform your measurements.

- Under optical microscope, measure the undercut between the top positive resist and the LOR resist.

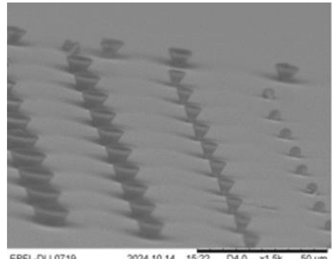


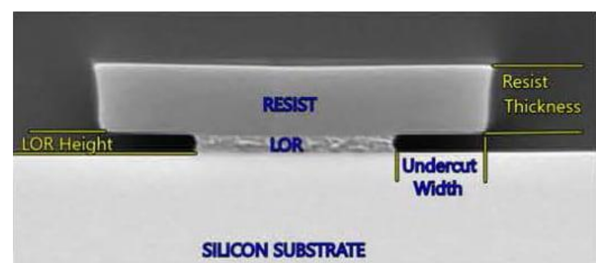
Undercut

SEM observation

After optical inspection, proceed to SEM characterisation for a more detailed analysis. Only sample having the following criteria will be observed by SEM:

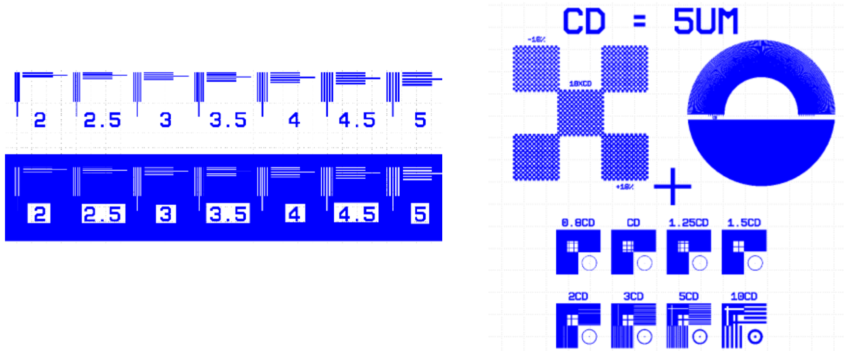
- **Negative slope** for negative resist nLOF 2070.
- **Undercut** for two-layer, positive resist(PR)/LOR.



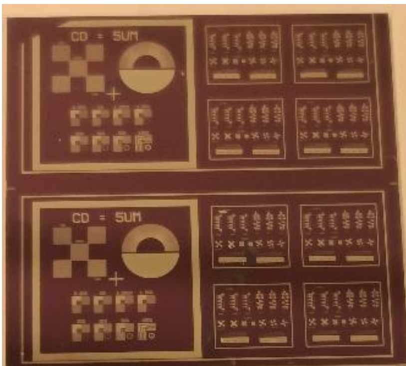


For cross section images of the selected samples, start by cleaving a portion off of each sample and loading them on an angle with respect to the electron beam in the SEM as shown below:

CD patterns

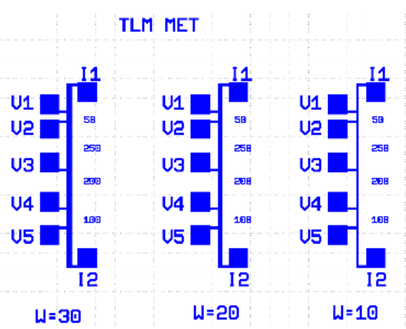


The above set of test patterns including lines and spaces at variable pitches as well as a checkerboard pattern are used to test the resolutions limitations of the process and how their shape and size change during the processing steps. As photoresist develops, lines narrow and disappear, while spaces widen. The presence of such test patterns reflects the photolithography quality. The number indicates the size of both the line and space in mm.

Before liftoff	After liftoff
	

- From both samples, note which lines and spaces are visible and intact on your wafer.
- Select one structure, measure its dimensions, and compare them with the values on the mask as designed.

TLM: Transfer Line Method



Under the TLM MET are patterns of resistor.

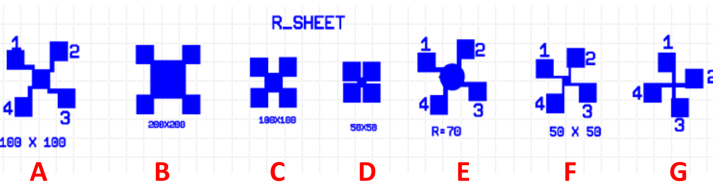
- Take an image of the following patterns at the same magnification. To extract the maximum information from your image, a higher magnification is recommended for images requiring high resolution.
- Measure the width of the aluminum wire.

W_{mask} (µm)	30	20	10
W_{opt} (µm)			

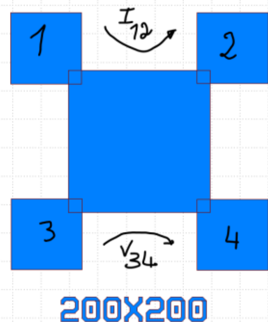
W_{mask} : Width of the design on the mask
W_{opt}: Width by optical measurement

Electrical characterisation

Sheet resistance: Van der Pauw method



The above test patterns are Van der Pauw structures which are also used for sheet resistance measurements. A typical combined test structure for a Van der Pauw setup is configured as a Greek cross, as shown below:



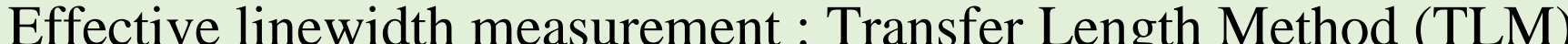
Sheet resistance is measured using the Greek cross. Current is applied between two adjacent pads 1 and 2, while the voltage is measured between the other two adjacent pads 3 and 4. From these measurements, the sheet resistance, R_s, is calculated using the formula:

$$R_s = \frac{\pi}{ln2} \times \frac{V_{34}}{I_{12}} \qquad \left({ohms}/{square}, {\Omega}/{\blacksquare} \right)$$

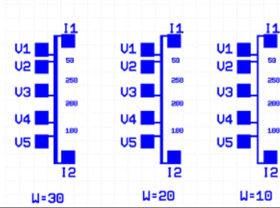
- Complete the following table :

Structure	A	B	C	D	E	F	G
R_s (unit)							

- What do you think about these values ?

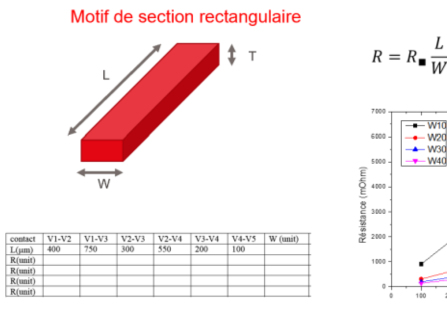


Effective linewidth measurement : Transfer Length Method (TLM)



Below the words "TLM MET" are 3 metal resistor structures with widths of 10, 20 and 30 µm. This configuration enables the measurement of resistors with varying lengths. By plotting the resistance values against the resistor length, a linear fit can be applied. The resulting slope enables the determination of the actual metal width of the resistor.

Note: The line widths indicated on the mask are the line widths of the lines as designed. The actual line width on a wafer will vary due to development and etching.



contact	V1-V2	V1-V3	V2-V3	V2-V4	V3-V4	V4-V5	W (unit)
L(µm)	400	750	300	550	200	100	
R(unit)							
R(unit)							
R(unit)							
R(unit)							

- For each of the structures measure the resistance for each of the lengths and complete the following table:

contact	V_{12}	V_{13}	V_{23}	V_{24}	V_{34}	V_{45}	W_{mask} (µm)
L(µm)	50	300	250	450	200	100	
R(unit)							10
R(unit)							20
R(unit)							30

- Plot R versus L and calculate the slope of the curve.
- From R_s and the slope of the curve R versus L, calculate the width of the measured structure.
- Compare this value with the value of the mask W and the optical measurement.
- Knowing the thickness of the aluminum film (measure extracted from topic 4 in the cleanroom session), determine the resistivity of the film?

- Comparing electrical and optical measurements:
- Complete the following table:

	Liftoff method		Etching method	
W_{mask}(µm)	W_{opt} (µm)	W_{elec} (µm)	W_{opt} (µm)	W_{elec} (µm)
10				
20				
30				

W_{mask} : Width of the design on the mask
W_{opt}: Width by optical measurement
W_{ele}: Width by electrical measurement.

- What is your conclusion?

- How the experimental parameters affect the profile and the size of the patterns?