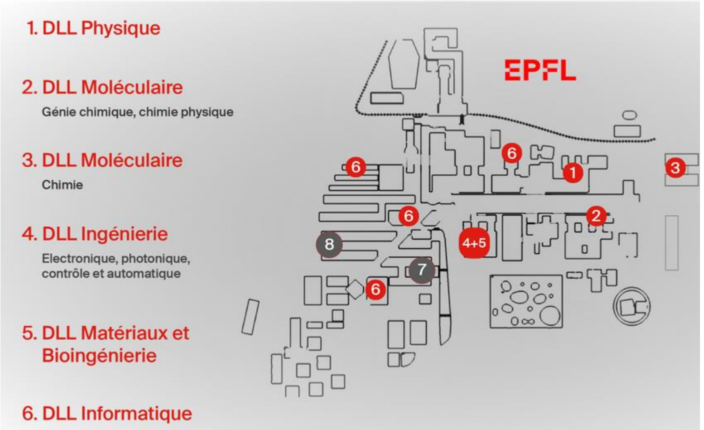
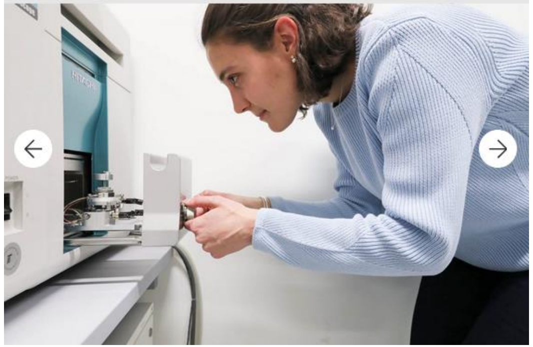
EPFL

MICRO-332
Microfabrication practicals
Travaux pratiques en microfabrication

DLL MED3 1119

DLL :Discovery Learning Laboratories

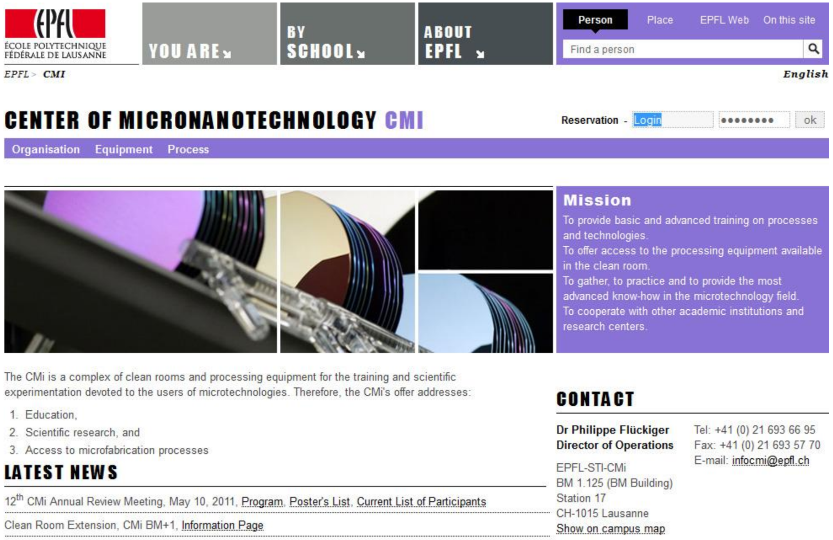





SPTS LPX


arias

CMi Website



CMi website tour :

http://cmi.epfl.ch/

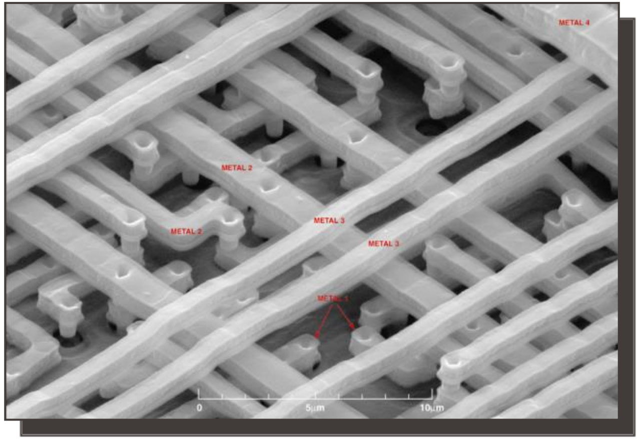
Equipment user manual

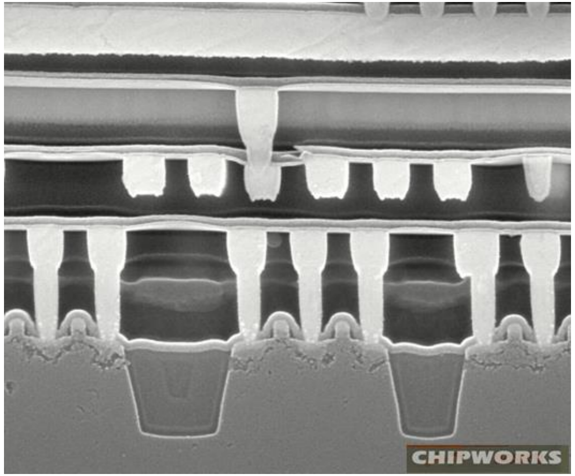
Equipment reservation

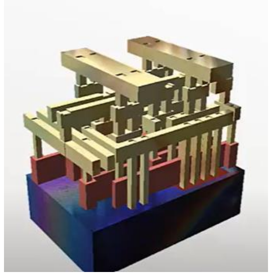
Material ordering…

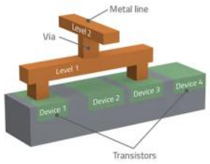
- Composants intégrés = empilement de motifs en films minces : électrodes, couches actives, isolantes ou protectrices

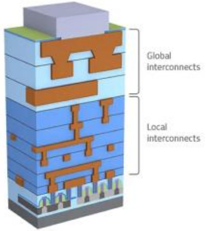
- Réalisation nécessite plusieurs étapes successives de photolithographie





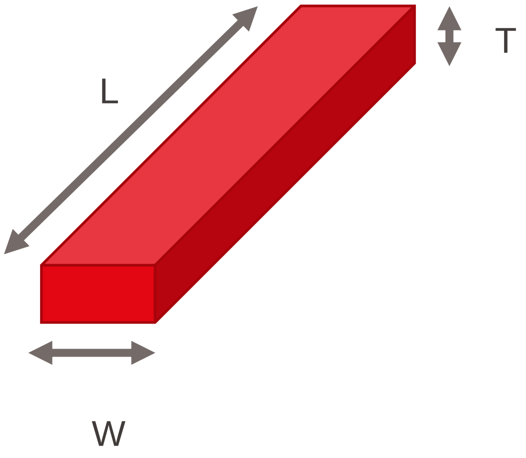




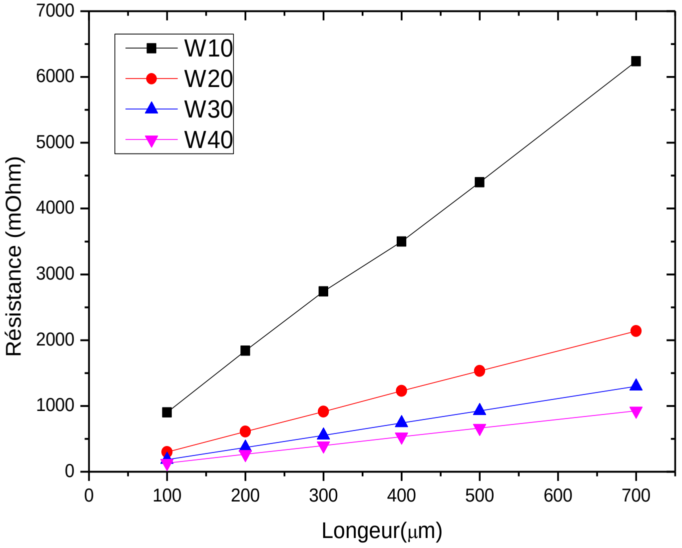


Résistance électrique

Fil métallique de section rectangulaire



$$R = \rho \frac{L}{W.T}$$

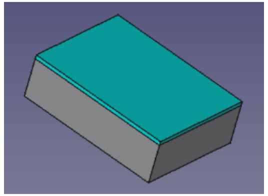


L (longueur) et W (largeur)

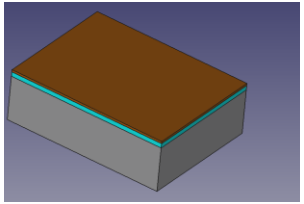
ρ Résistivité du film

T Epaisseur du film

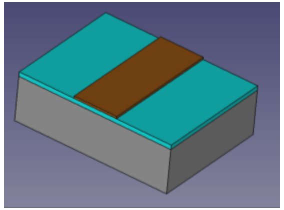
Déposition
Du métal



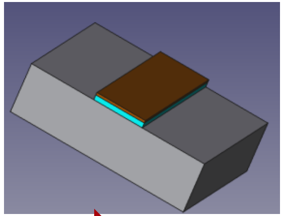
Déposition
de la résine



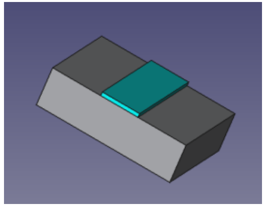
Résine après
exposition UV
et développement



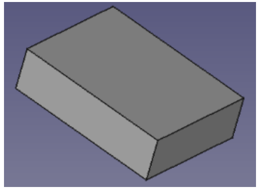
Après gravure
du métal



Après élimination
de la résine

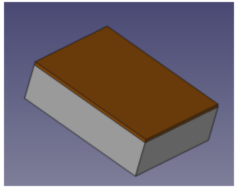


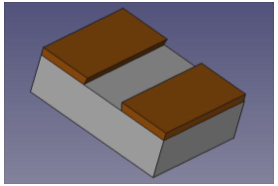
Procédé: Gravure chimique

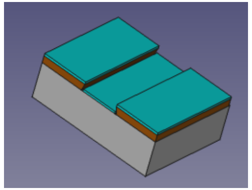


Substrat

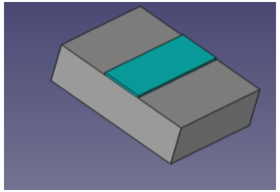
Procédé: Liftoff







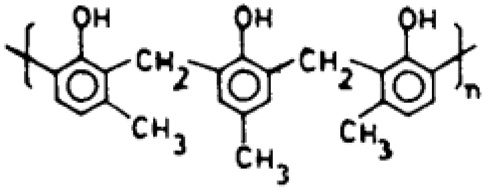
Après déposition
du métal



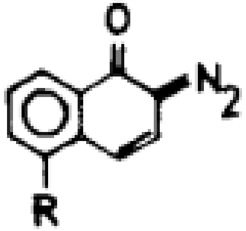
Topic 2 :
Résine positive
Courbe de contraste
Epaisseur de résine en fonction de la vitesse de rotation.

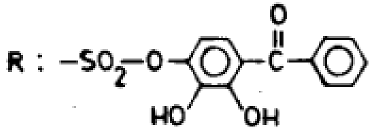
Résine photosensible positive

- Une résine est composée de 3 éléments essentiels :
  - Polymère inactif : matrice du film Novolaque (10-40%)



•Elément photo actif (PAC) diazonaphtoquinone (DNQ) (1-5%)



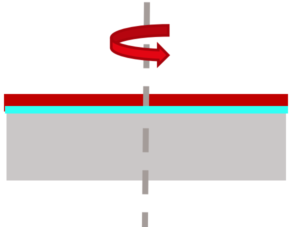


•Solvant: contrôle la viscosité de la résine propylène-glycol-monométhyl-éther-acétate (PGMEA) (50-85%)

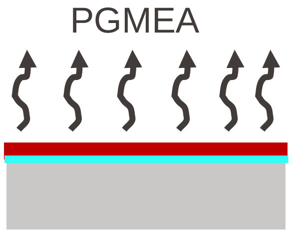
Etapes de fabrication: Résine positive

1. Nettoyage de la surface

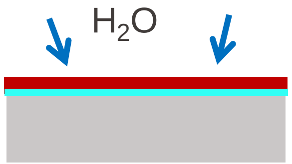
2. Silanisation : HMDS



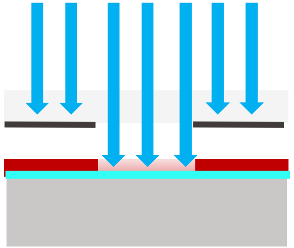
3. **Etalement de la résine**



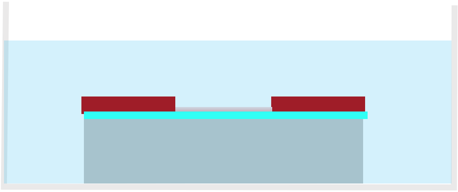
4. Pré-recuit



5. Relaxation: rehydratation



6. **Exposition aux UV**



7. **Développement**

8. Caractérisation

Process flow & Feuille de route

Lab :
Operator Name :
Supervisor Name :
Process Flow Date :
Phone :
Office :
E-mail :

CMi EPFL Center of MicroNanoTechnology

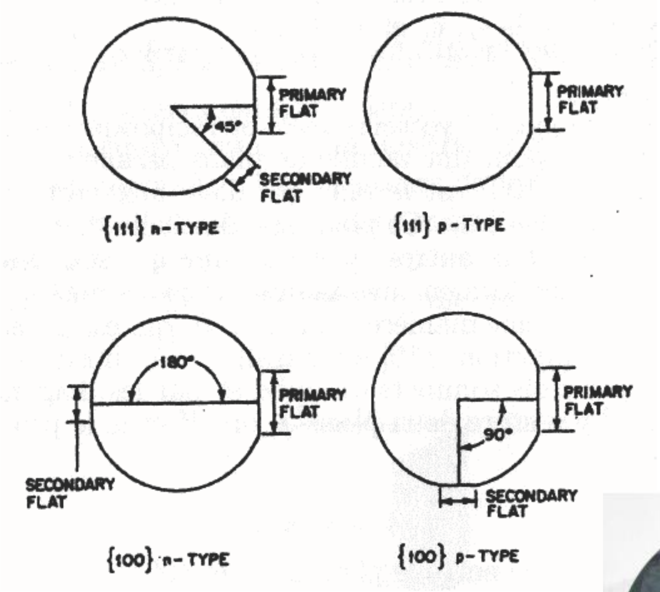
Step-by-step process outline

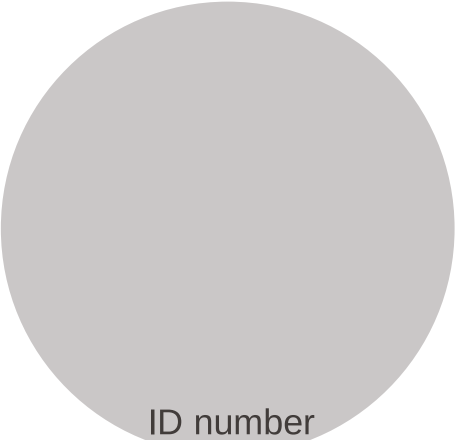
Step	Process description	Cross-section after process
01	**Substrate**: *Si test* *Wet Oxidation* Machine: *Centrotherm* Thickness: *0.5 µm*	
02	*Photolith PR coat* Machine: *EVG150* PR : *AZ1512 – 1.1µm*	
03	*Photolith expo+ develop* Machine: MA + EVG150 Mask : *CD = 5um* *Align wafer flat* *+ short O2 plasma Descum* *(10s Tepla low – Z2)*	
04	*Dry Etch* Material : *Si02* Machine: *SPTS* Depth : *0.5 µm*	
05	*Resist Strip* Material: *AZ1512 – 1.1µm* Machine: Tepla + Remover	
06	*Photolith PR coat* Machine: *EVG150* PR : AZ1512 on LOR – 1.5+0.5 *um*	

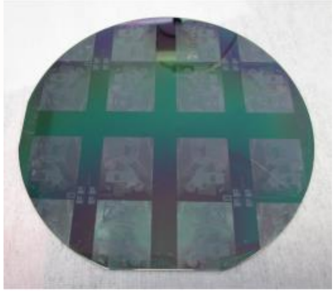
Step	Description	Equipement	Program / Parameters	Target	Actual	Remarks
1	**WAFER PREPARATION**					
1.1	Stock out "litho" wafers					
1.2	Stock out "align" wafers					
1.3	Check	Z15/F20 Thin-Film Analyzer				First calibrate on sample Si wafer
2	**PHOTOLITHOGRAPHY: "LITHO"**					
	Check machines	Z13/SSE coater		100mm chuck in position		
		Z13/SSE hotplate		**100°C**		
		Z13/MJB4		Lamp on		
2.1	HMDS priming					
2.2	AZ1512HS coating					
2.3	AZ1512HS softbake					
2.4	AZ1512HS relaxation time					
2.5	AZ1512HS expose					
2.6	AZ1512HS expose					
2.7	AZ1512HS develop					
2.8	Water cleaning					
2.9	Inspection					
3	**MEASUREMENTS: "LITHO"**					
3.1	AZ1512HS thickness					
4	**MEASUREMENTS: RESOLUTION**					
4.1	Resolution of structures			Correctly exposed, underexposed and overexposed regions.		
4.2	Alignment quality			Measurements on Vernier microstructures.		

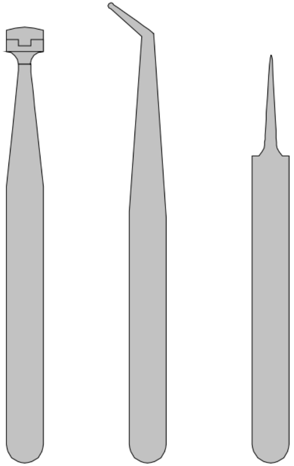
Identification du substrat

Orientation et dopage, numéro d'identification



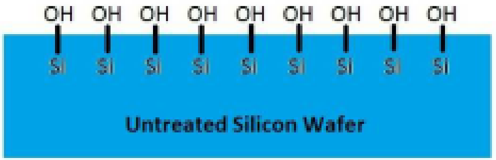






Préparation de surface: nettoyage et promoteur d'adhérence

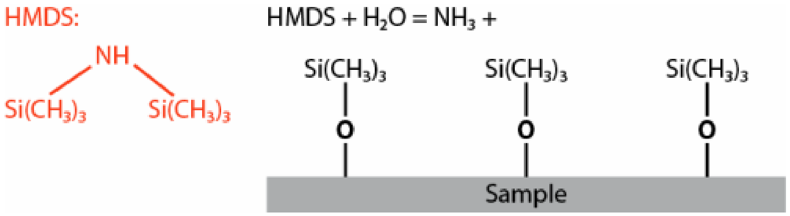
- But : améliorer l'adhésion et l'uniformité de la couche de résine à la surface du substrat.
- Problème: l'oxyde native du silicium rend la surface hydrophile
  - absorbe humidité

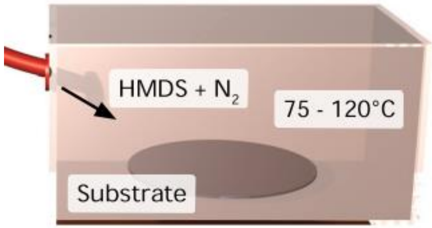


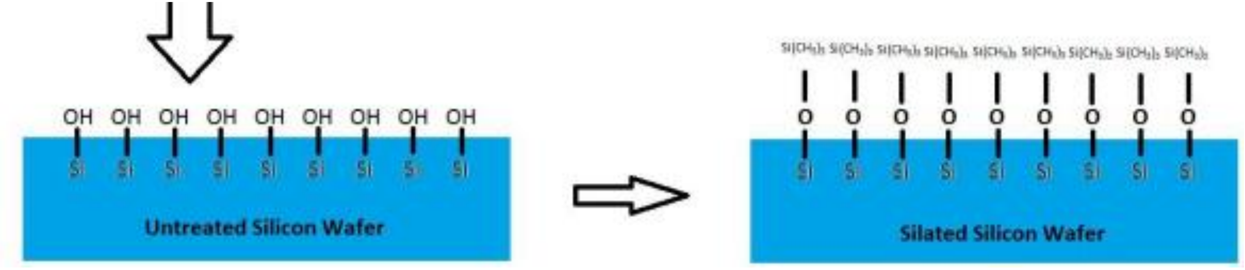
- Solution:
  - Déshydratation: élimination d'humidité à la surface du substrat
    - Recuit thermique à 120 °C pendant quelques min
    - Désorption des liaisons –OH
  - Silanisation: déposition en phase gazeuse du silane hexamethyldisilazane (HMDS) à la surface du substrat

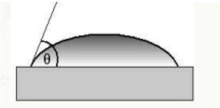
Préparation de surface

Hexamethyldisilazane (HMDS)

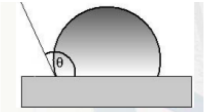








Hydrophilic
(before HMDS treatment)

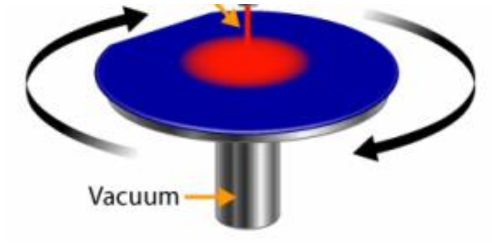


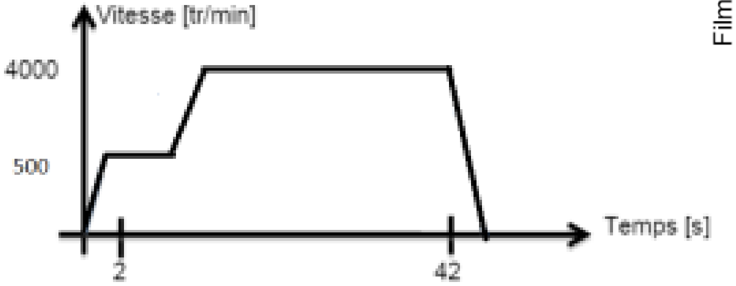
Hydrophobic
(after HMDS treatment)

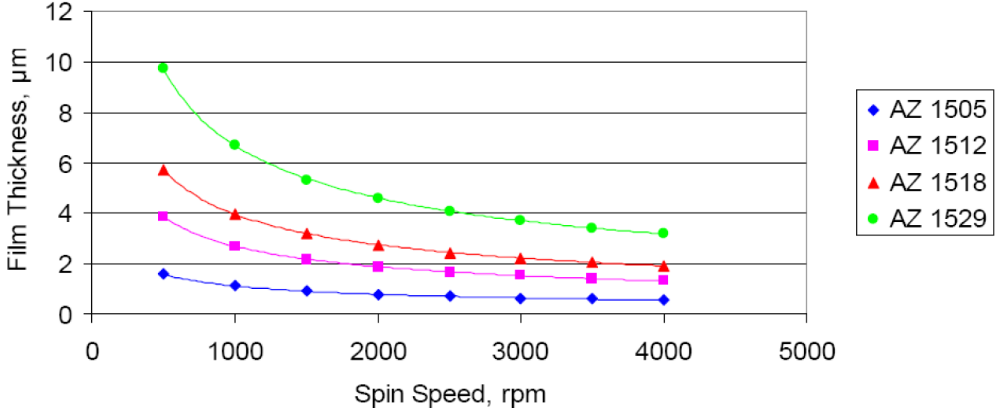
Déposition de la couche de résine

- Etalement à la tournette
- Obtenir une couche de résine uniforme

Résine liquide



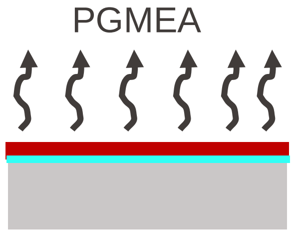




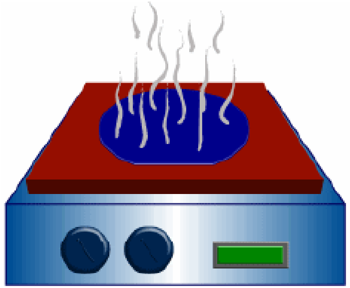
$$e = \frac{kp^2}{\sqrt{v}}$$

e : épaisseur de la résine (µm)
k : constante de la tournette
p : viscosité (cP)
v : vitesse de rotation (tr/mn)

Pré-recuit

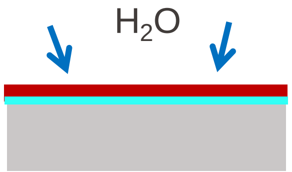


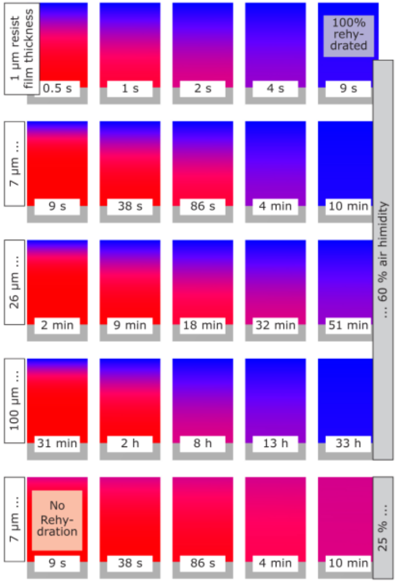
- Elimination des solvants (réduction de l'épaisseur).
- Amélioration de l'adhésion de la résine au substrat
- Réduit les contraintes créées dans la résine pendant la centrifugation
- Température de recuit: élément très important
  - A softbake at 100°C on a hotplate for 1 min per µm resist film thickness. At 110°C, halve the softbake time, while for each 10°C below 100°C the time should be doubled
  - Température élevée:
    - la résine réagit avec l'oxygène dans l'air et conduit à la formation de fissures
    - Décomposition du photo-initiateur
  - Température faible:
    - Élimination du solvant n'est pas suffisante
    - Cause des problèmes lors de l'exposition aux UV



Relaxation/réhydratation

- Refroidissement du substrat (atteindre la température ambiante) .
- Minimiser la dilatation thermique induite par la température
- Permettre à la vapeur d'eau de diffuser dans la résine. Sa présence est nécessaire pour le réaction chimique durant l'exposition aux UV.
- H_2O provient de l'humidité en salle blanche (>40%)

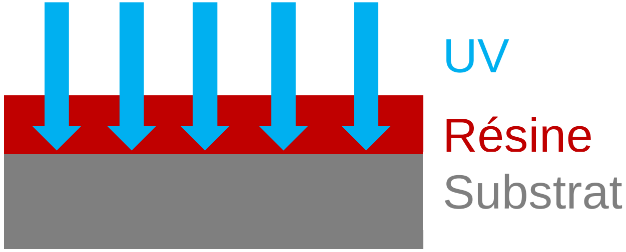


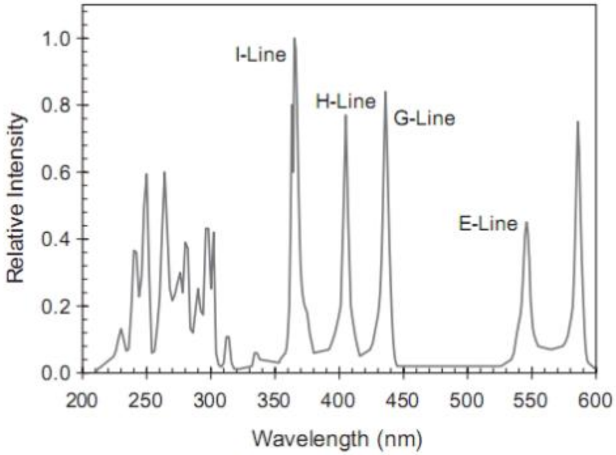


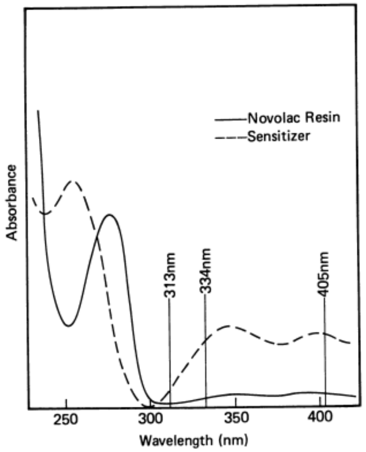
Exposition aux UV

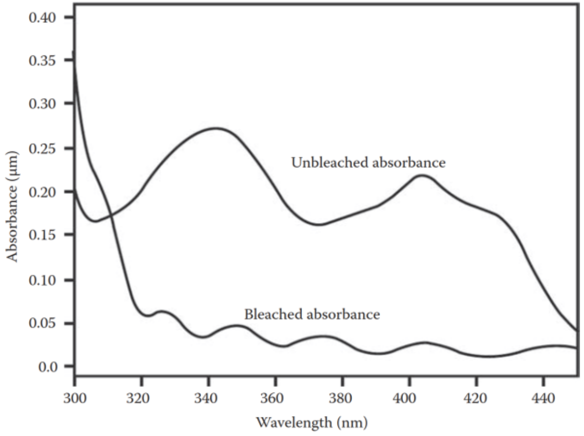
UV light : λ= 365 nm

I_{lamp} # mW/cm^2



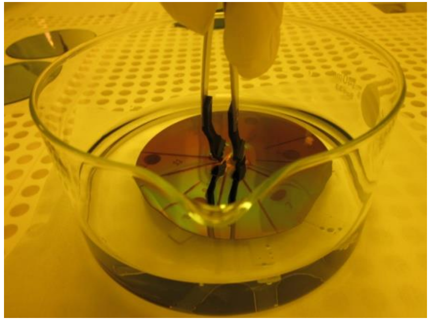


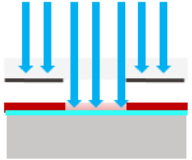




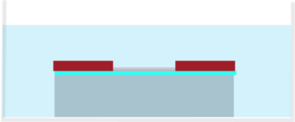
Développement

- Dissolution de la résine exposée aux UV dans une solution de développement
  - MIF (metal ion free) (Souvent TMAH) ne contient pas d’ion Na$^+$ et K$^-$
    - Utilisé essentiellement pour les composants électroniques et optiques
  - MIC (metal ion containing) (solution basique; NaOH, KOH)
    - Contient les ions Na+ et K- pouvant contaminer les composants électriques.
    - Souvent utiliser dans MEMS et les photomasques
- Concentration de la solution et du temps de développement





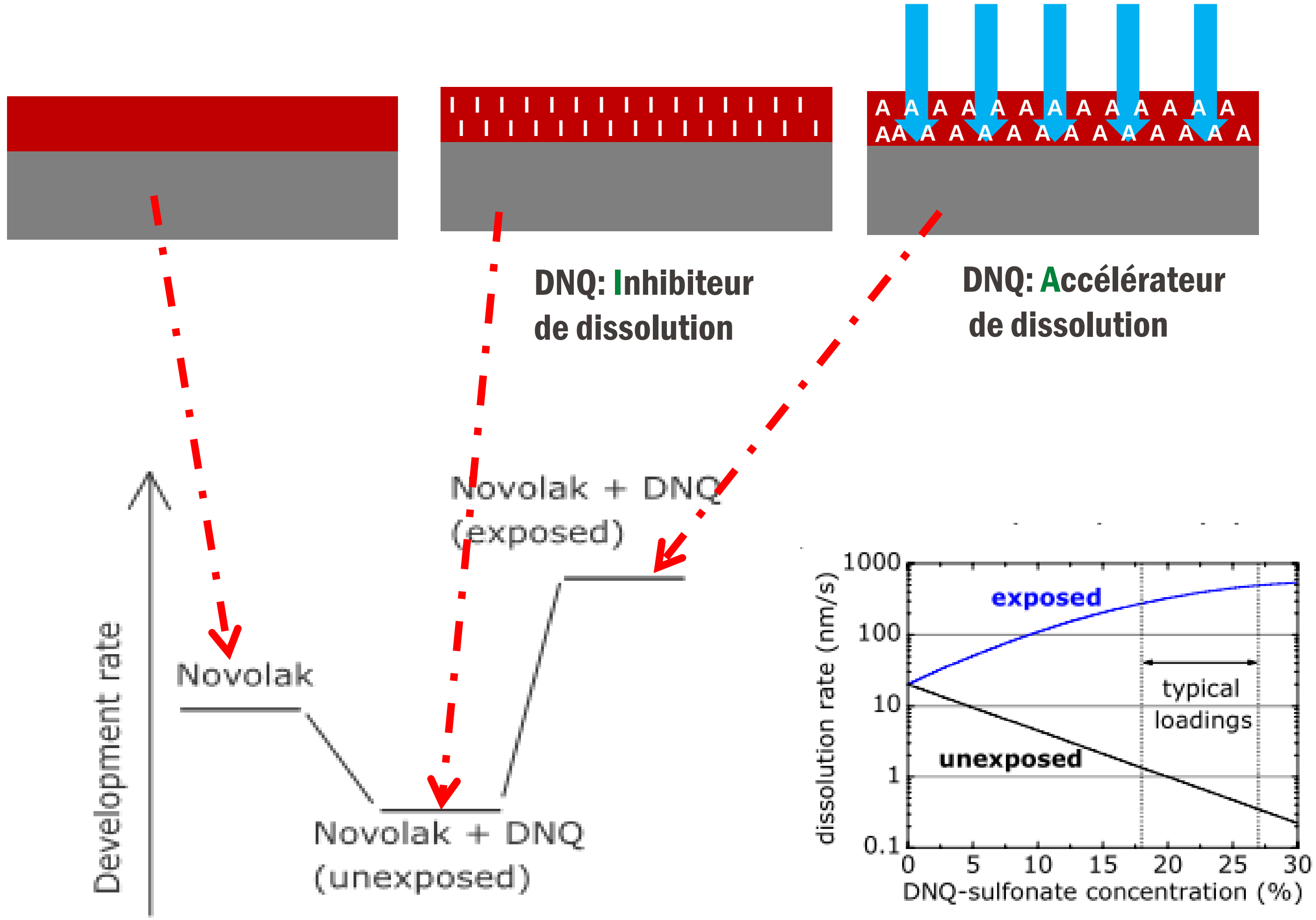
6. **Exposition aux UV**



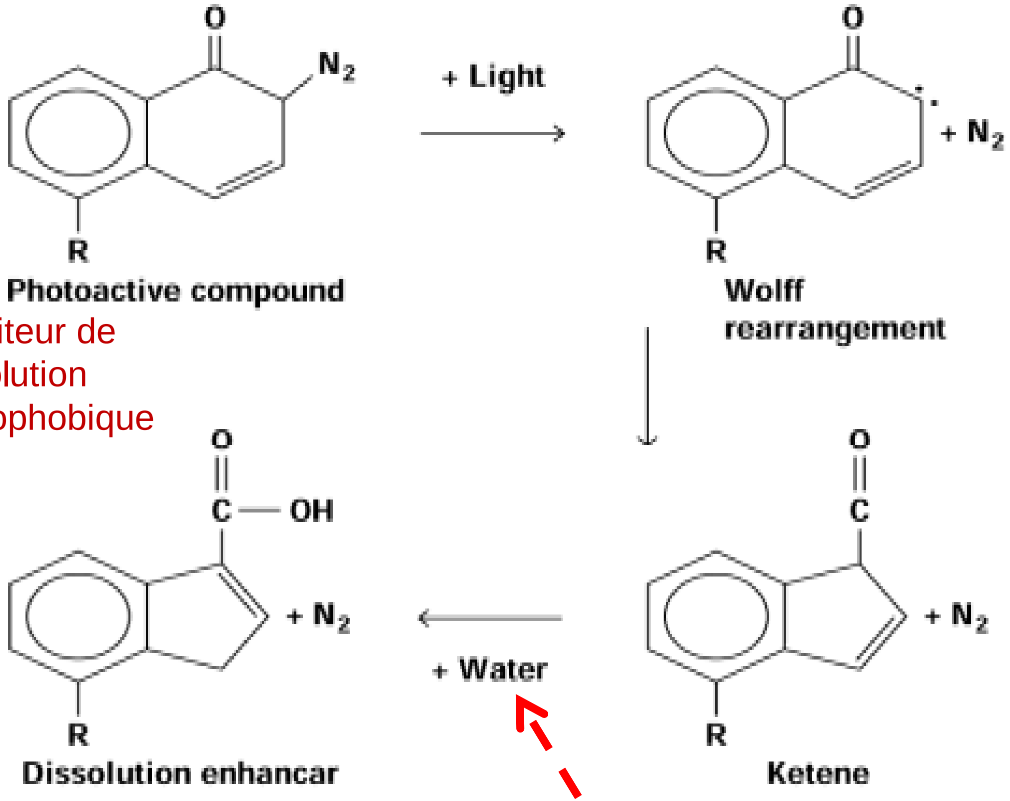
7. **Développement**

8. Caractérisation

Résine positive: Novolak +DNQ



Résine positive: DNQ photoinitiateur

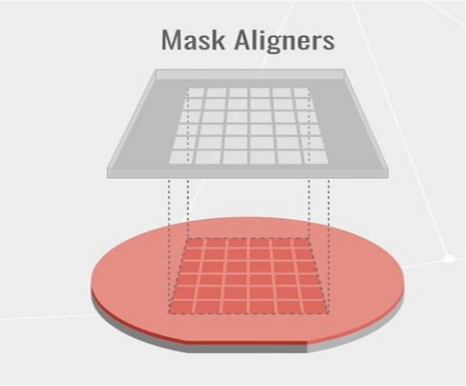


1. Inhibiteur de dissolution
2. hydrophobique

1. Accélérateur de dissolution
2. hydrophilique

Eau provient de l'humidité > 40%

Effet de la lumière blanche



Salle de lithoraphie : éclairage lumière jaune

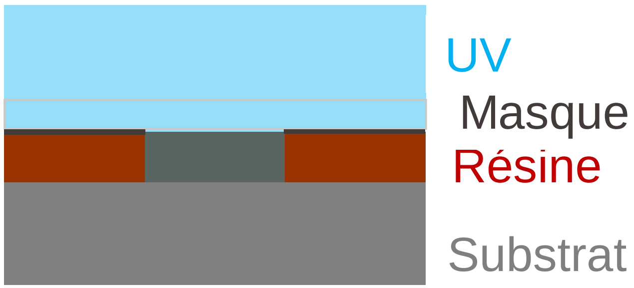
Courbe de contraste

Variation de l'épaisseur normalisée en fonction de la dose d'exposition

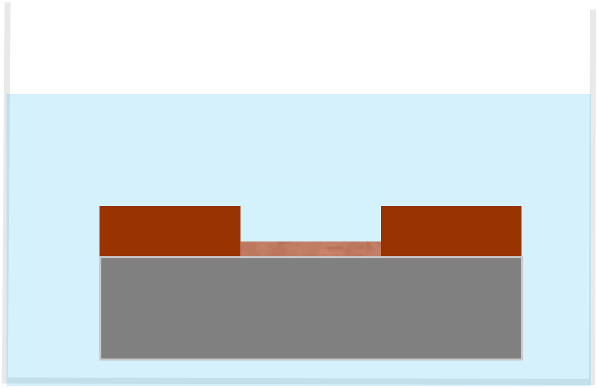
$$Epaisseur\ normalisée = \frac{E_f}{E_i}$$

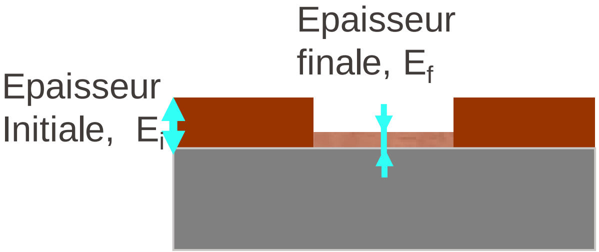
$$\text{Dose d'exposition} = I_{lampe} \times t_{\exp}$$

I_{lampe}= Intensité de la lampe (mW/cm^2)
t_{exp}= temps d'exposition (sec)



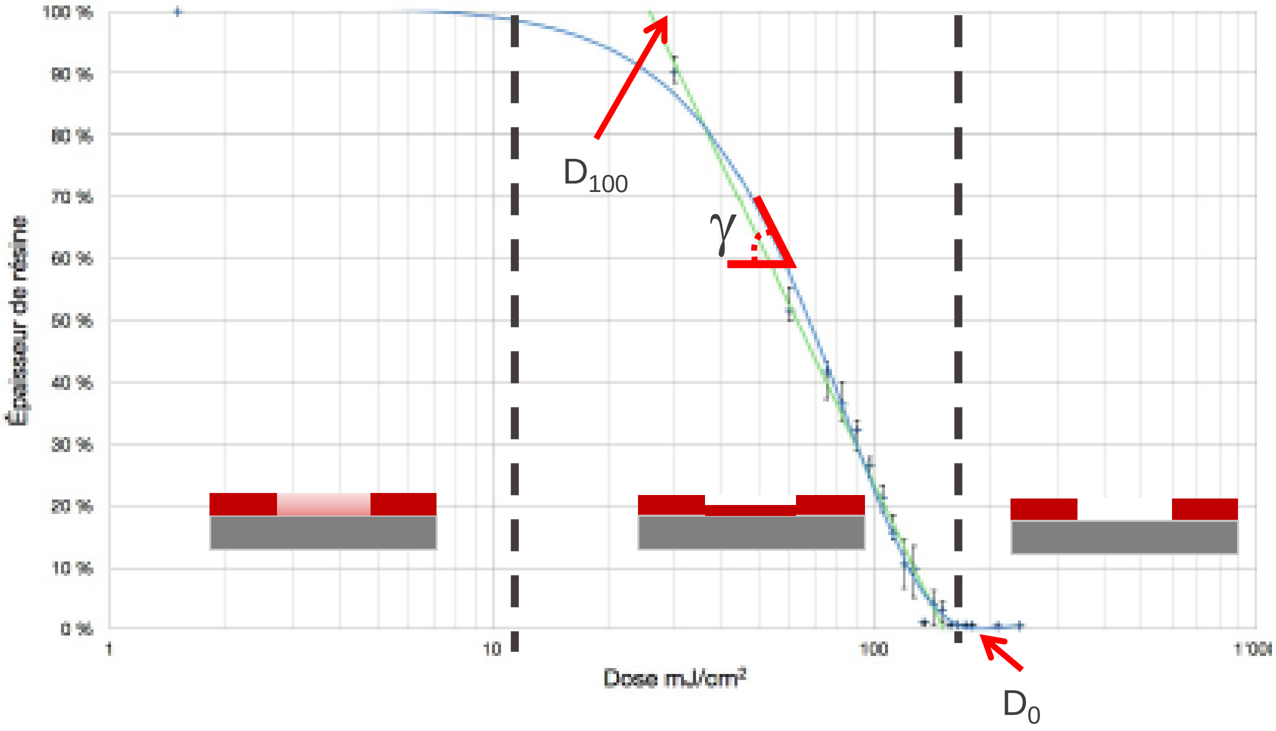
Exposition aux UV, t_{exp}





Développement, t_{dev}

Courbe de contraste: résine positive

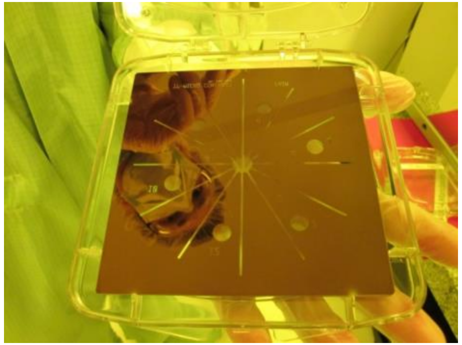


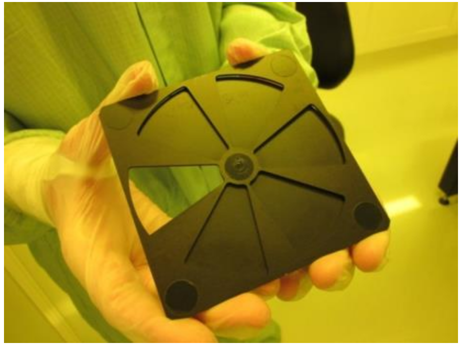
- Sensibilité de la résine: D_0
- Contraste de la résine : γ

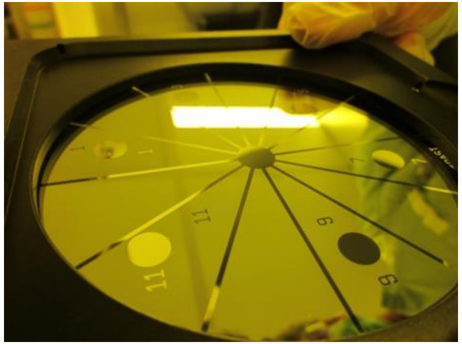
$$\gamma = \frac{1}{\log\left({D_0}/{D_{100}}\right)}$$

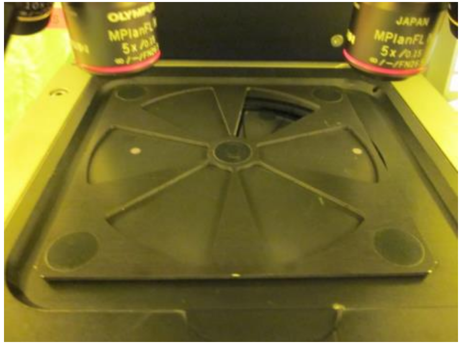
EPFL

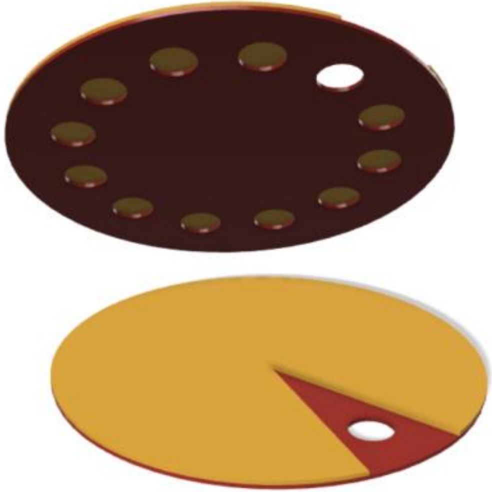
Masques pour la courbe de contraste

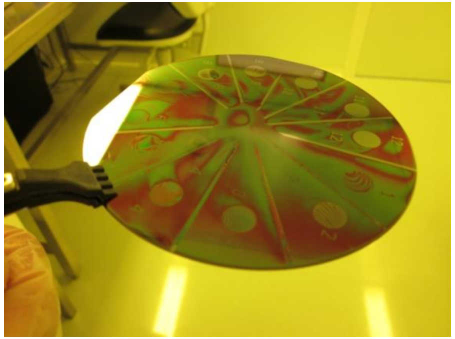






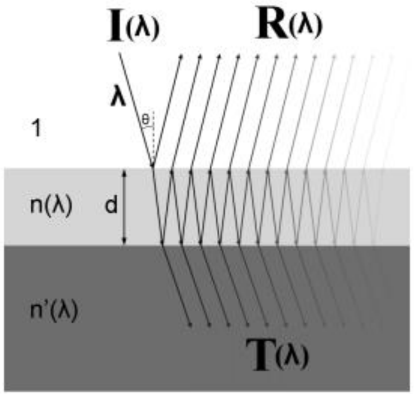


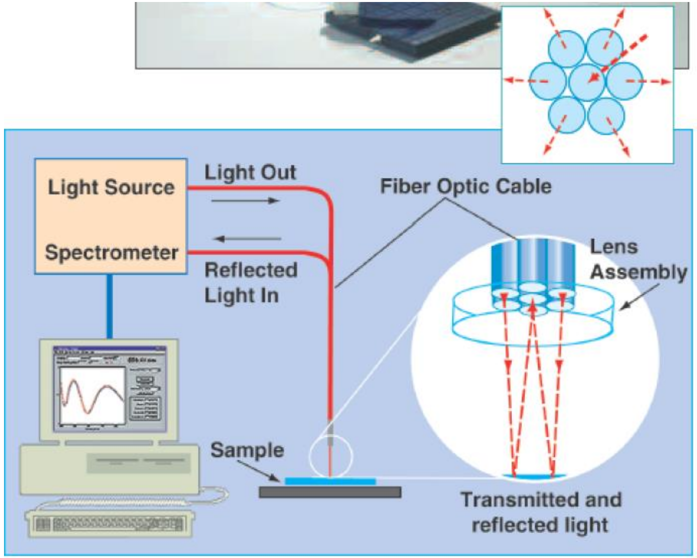




Mesure par réflectance

- The light intensity reflected from the sample at a normal incidence is measured over the range of wavelengths
- Computer software uses the property of dispersion of index refraction of the film to determine the film thickness.
- Non-destructive and non-contact
- Simple and relatively low cost

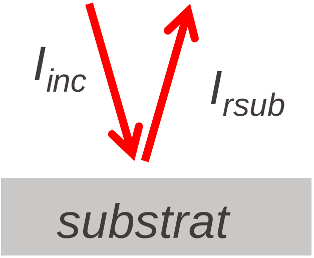


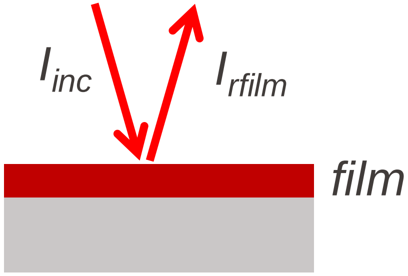


Principe de mesure

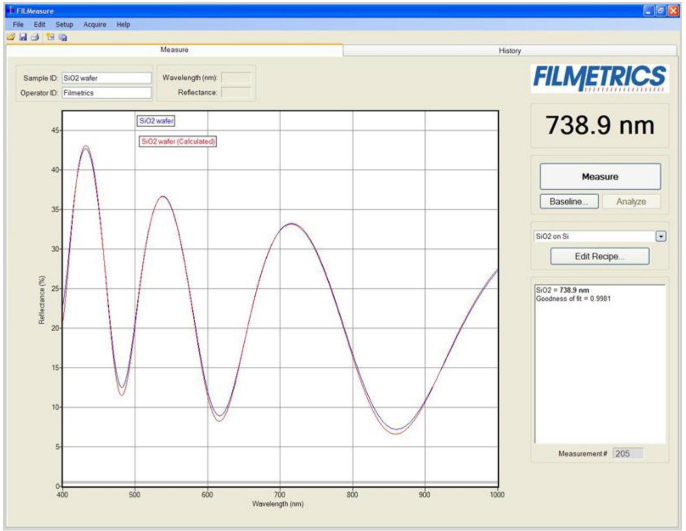
$$R_{film}(\lambda) = \frac{I_{rfilm} - I_{bkg}}{I_{inc} - I_{bkg}} = \frac{I_{rfilm} - I_{bkg}}{I_{rsub} - I_{bkg}} R_{sub}(\lambda)$$

$$R_{sub}(\lambda) = \frac{I_{rsub} - I_{bkg}}{I_{inc} - I_{bkg}}$$

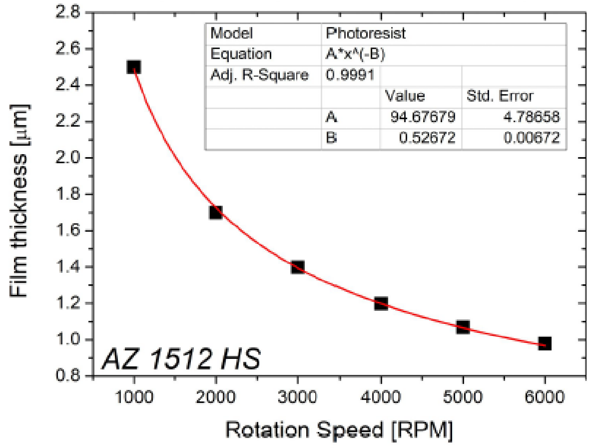


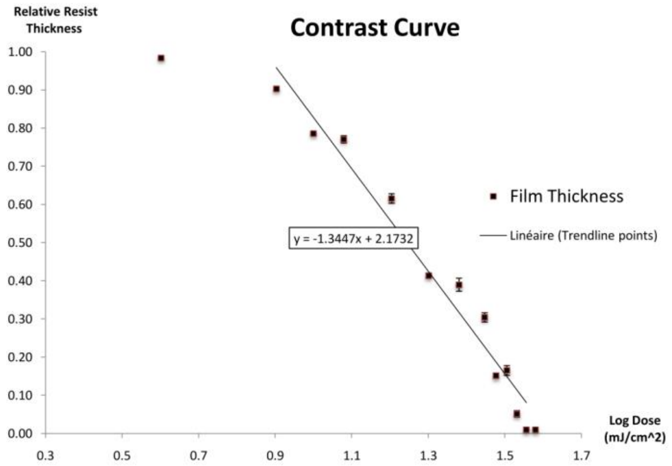


$$R(\lambda) = \frac{r_{01}^2 + r_{12}^2 + 2r_{01}r_{12}\cos\left(\frac{4\pi n_1(\lambda)d}{\lambda}\right)}{1 + r_{01}^2 r_{12}^2 + 2r_{01}r_{12}\cos\left(\frac{4\pi n_1(\lambda)d}{\lambda}\right)}$$

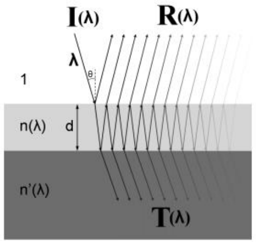


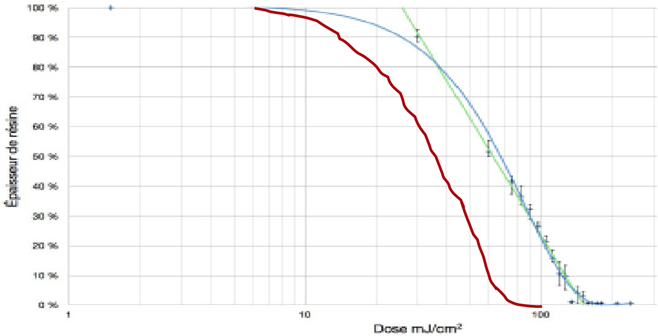
EPFL

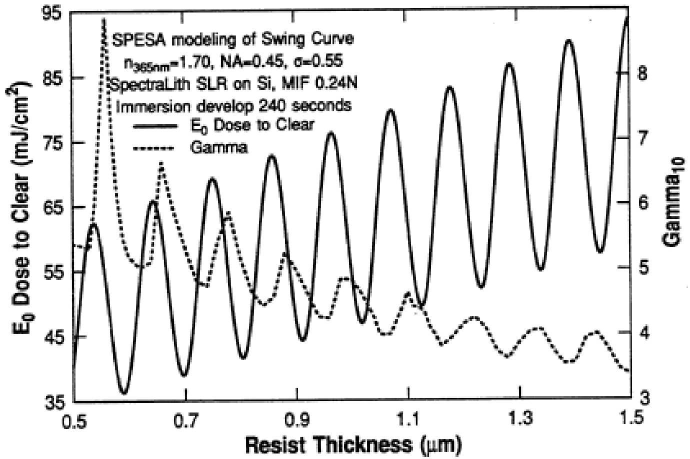

Model | Photoresist
Equation | A*x^(-B)
Adj. R-Square | 0.9991
Value | Std. Error
A | 94.67679 | 4.78658
B | 0.52672 | 0.00672
AZ 1512 HS
Film thickness [µm]
Rotation Speed [RPM]
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
1000
2000
3000
4000
5000
6000


Contrast Curve
Relative Resist Thickness
Log Dose (mJ/cm^2)
y = -1.3447x + 2.1732
Film Thickness
Linéaire (Trendline points)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7

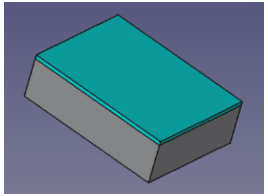
Effet de l'épaisseur de la couche de résine



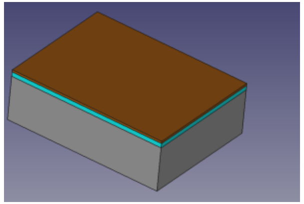




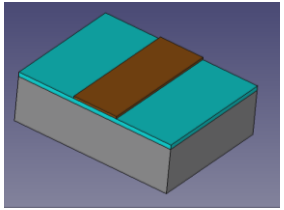
Déposition
Du métal



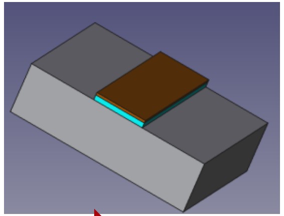
Déposition
de la résine



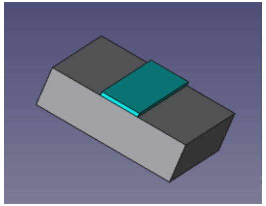
Résine après
exposition UV
et développement



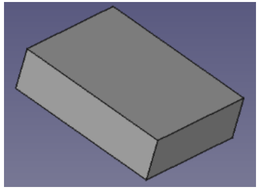
Après gravure
du metal



Après élimination
de la résine

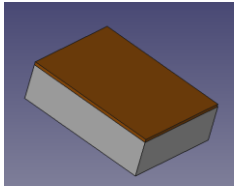


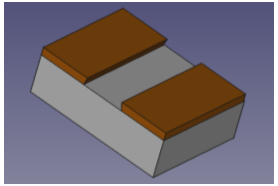
Procédé: Gravure chimique

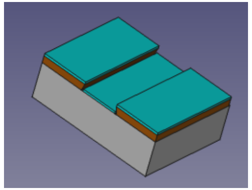


Substrat

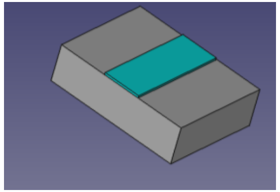
Procédé: Liftoff





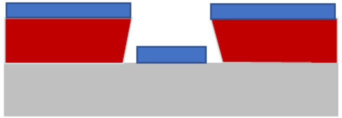


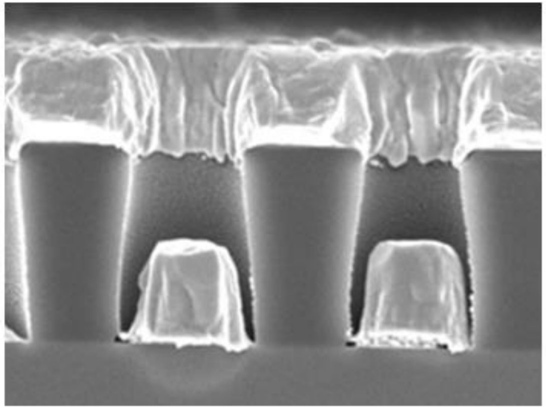
Après déposition
du metal

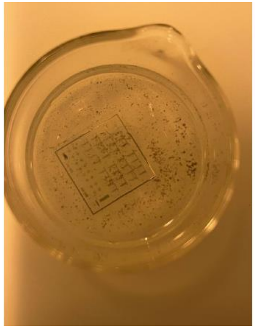


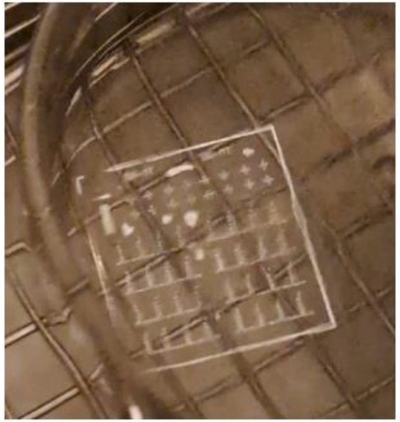
Topic 3 :
Résine négative
Liftoff
Angle de contact

Liftoff

Step	Process description	Cross-section after process
01	**Substrate**: Glass wafer • *Teply O_2 plasma treatment,*	
02	*Photolith PR coat* • *1.4 um AZ nLOF 2020 coating in ACS200,*	
03	*Photolith expo+ develop* • *4.7 sec exposure with MJB4 (94 mJ/cm^2)* • *Developing in ACS200,*	
04	*Metal deposition* • *20/200 nm Ti/Al in EVA760, 450 mm WD, dep. rate: 5 A/s*	



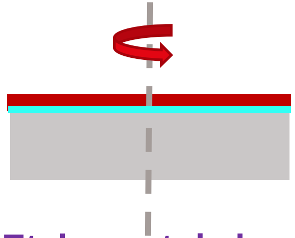




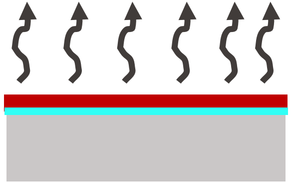
Etapes de fabrication : Résine négative

1. Nettoyage de la surface

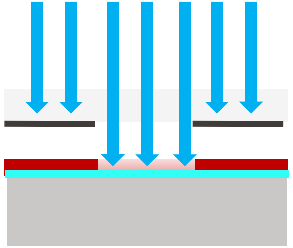
2. Silanisation : HMDS



3. **Etalement de la résine**

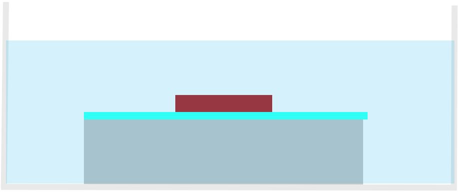


4. Pré-recuit



5. **Exposition aux UV**

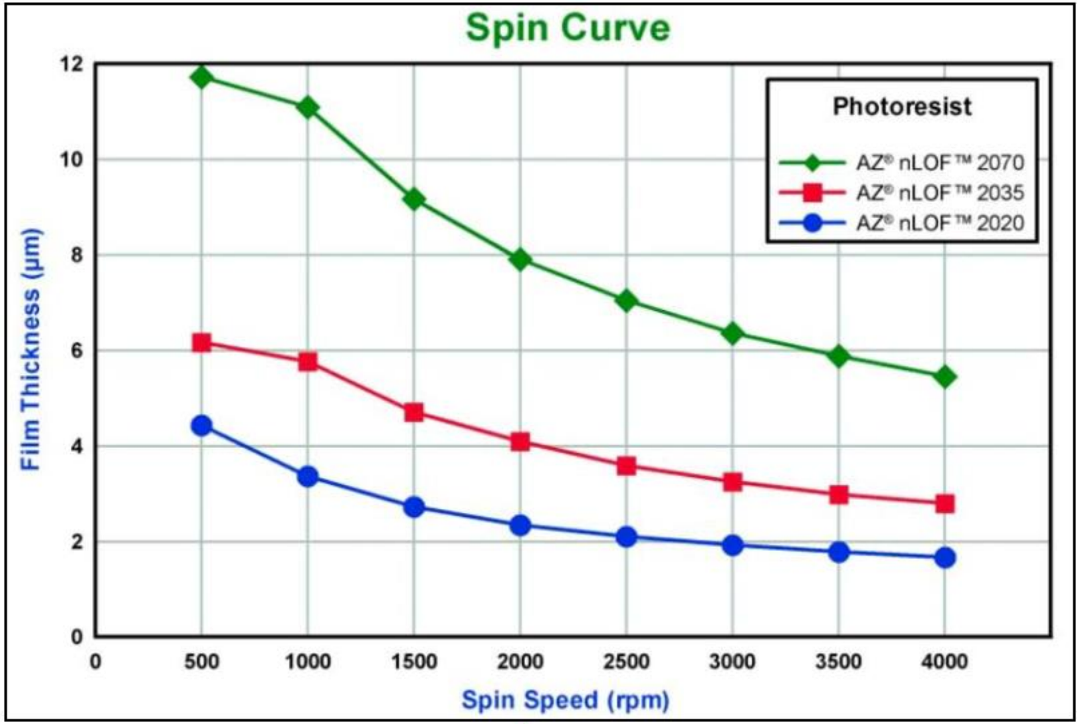
6. Post-recuit (PEB)



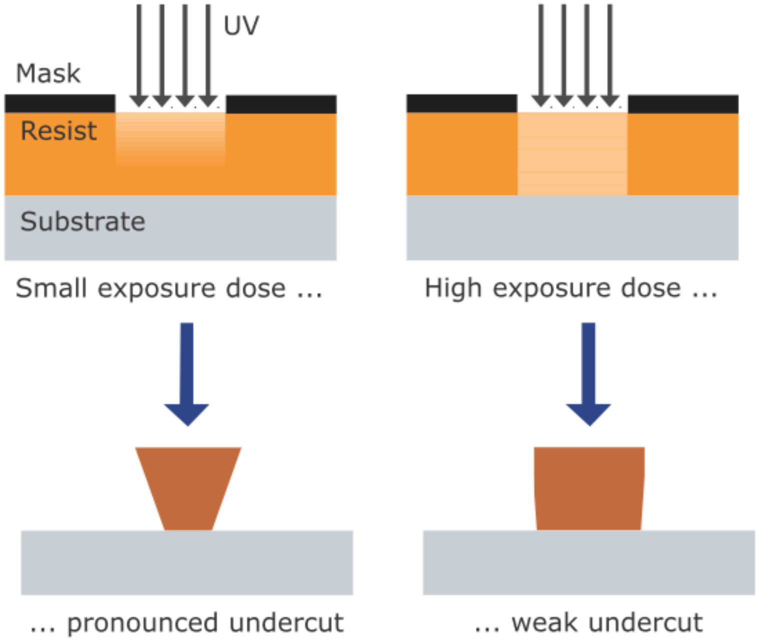
7. **Développement**

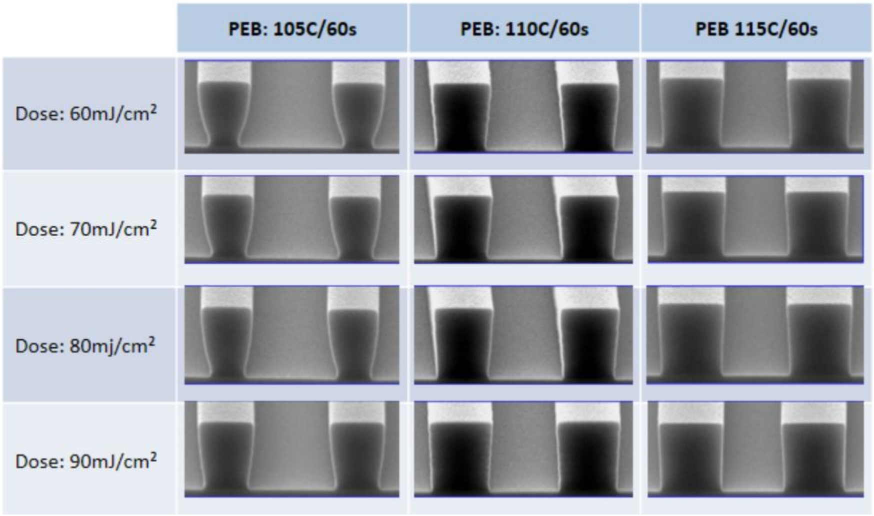
8. Caractérisation

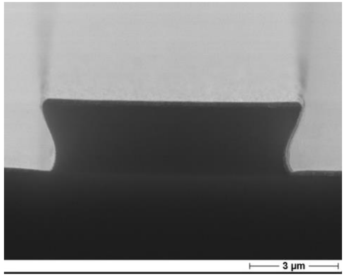
Résine Négative: AZ nLOF 2070

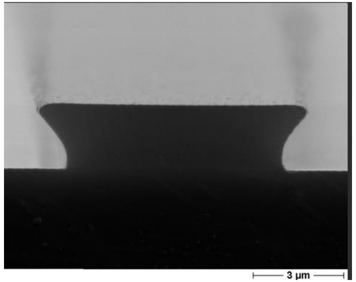


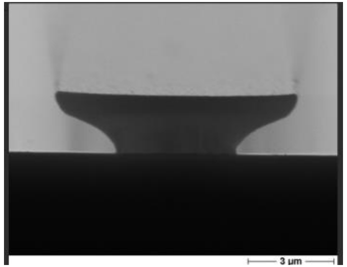
Résine négative

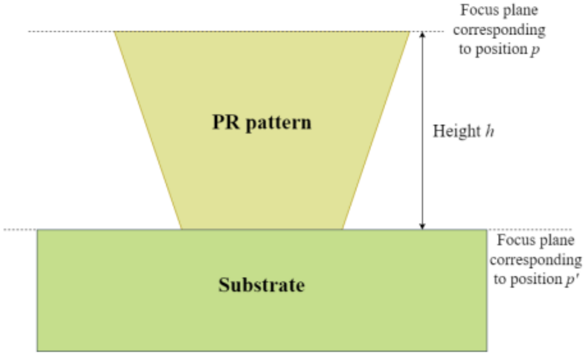


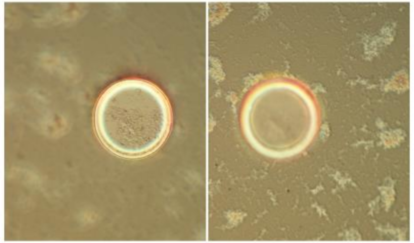


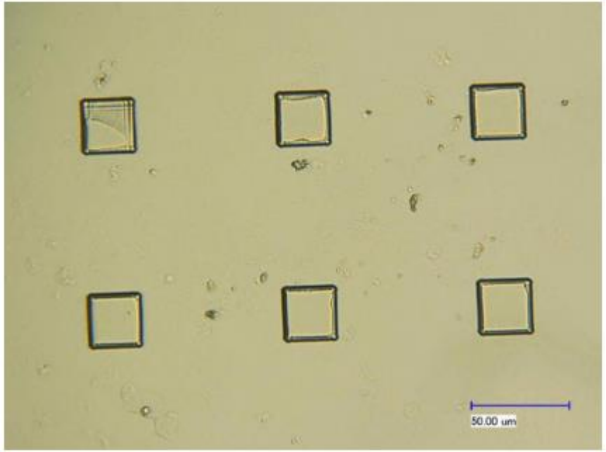

3 µm

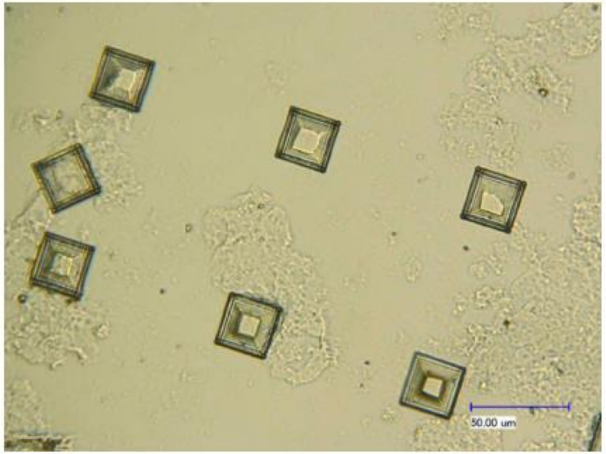

3 µm


3 µm


Focus plane corresponding to position p
PR pattern
Height h
Substrate
Focus plane corresponding to position p'

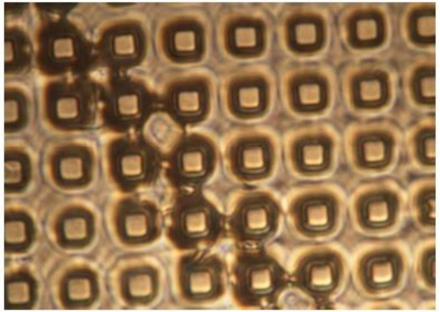


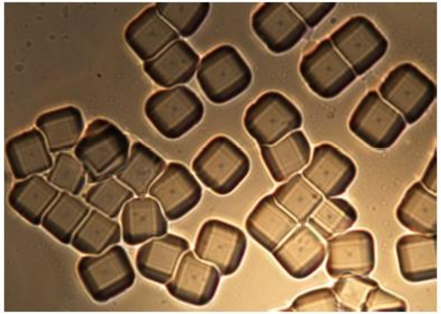

50.00 um

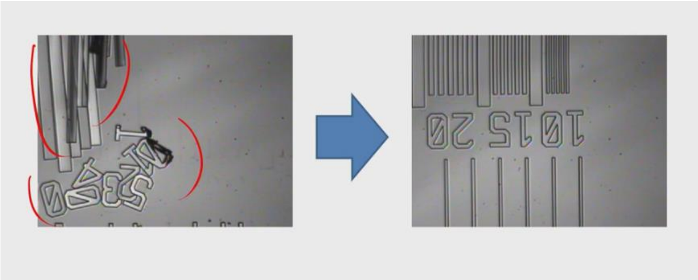

50.00 um

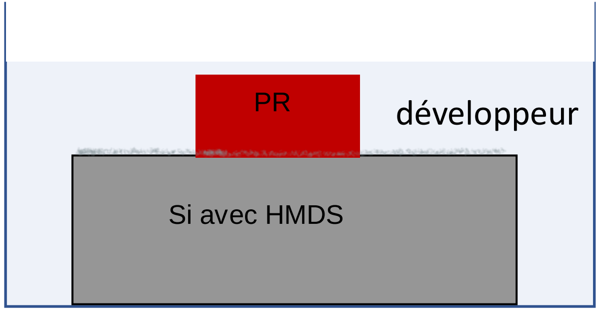
Préparation de surface

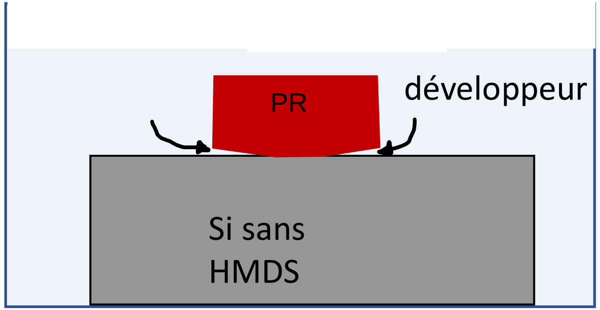
Pour avoir une bonne adhérence de la résine photosensible, l'angle de contact doit être compris entre 45° et 65°.



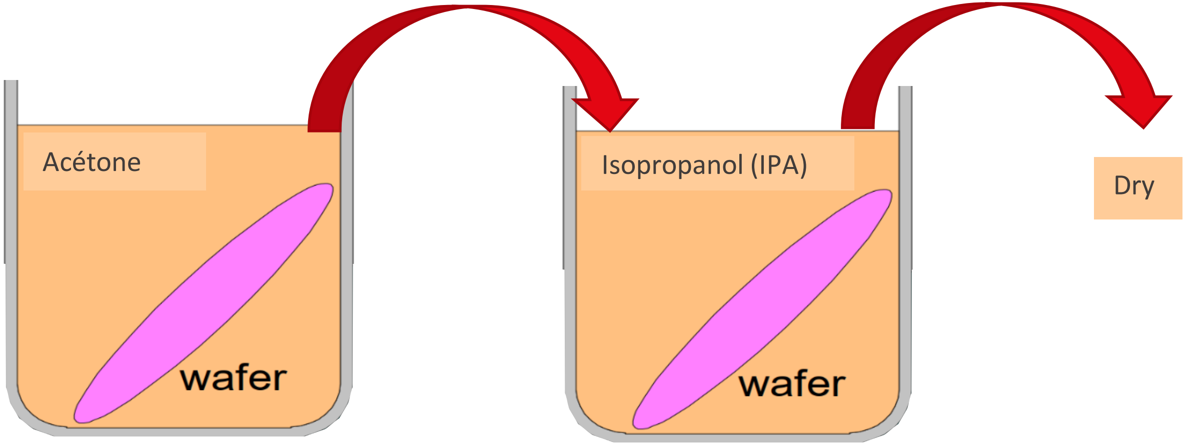


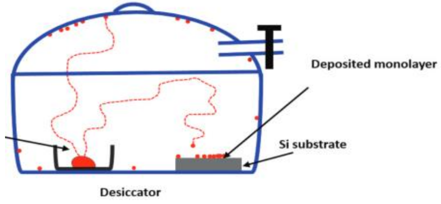






Nettoyage et promoteur d'adhérence



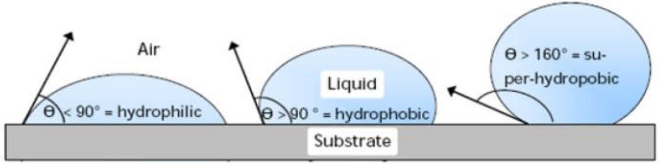


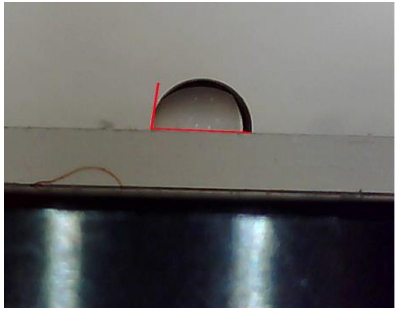
Les paramètres ayant une influence sur le dépôt du HMDS sont :

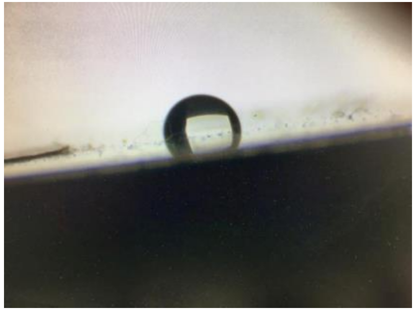
- la température
- la pression dans l'enceinte pendant le dépôt
- la durée du dépôt HMDS

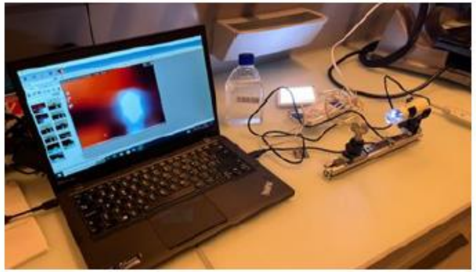
Angle de contact

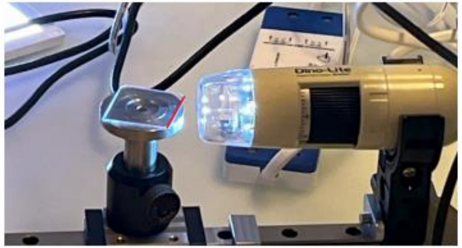
L’angle de contact est l’angle entre le substrat et la tangente de la goutte d’eau posée sur le substrat

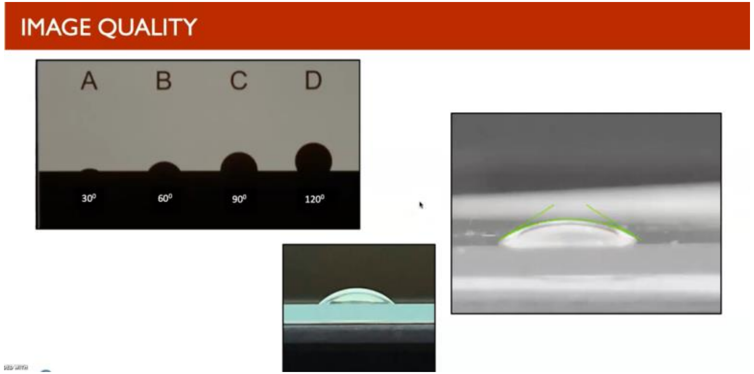




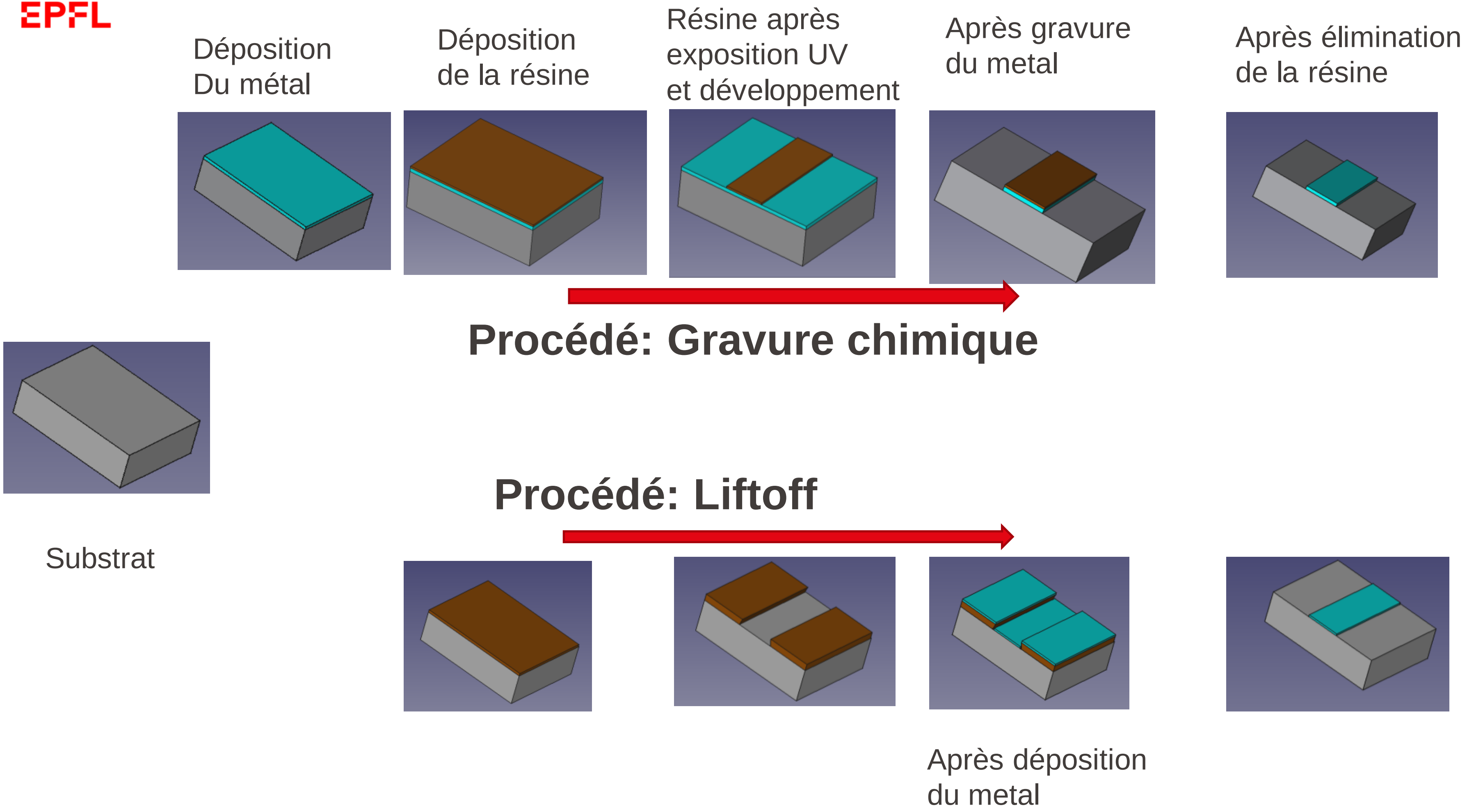








Topic 4:
Salle blanche
Alignement
Gravure chimique


Déposition
Du métal
Déposition
de la résine
Résine après
exposition UV
et développement
Après gravure
du metal
Après élimination
de la résine
Procédé: Gravure chimique
Substrat
Procédé: Liftoff
Après déposition
du metal

Topic clean room

CMI: Centre of MicroNanoTechnology

Habillement

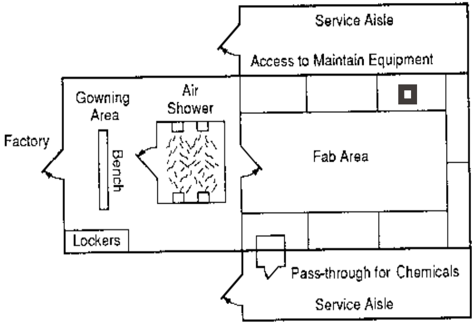
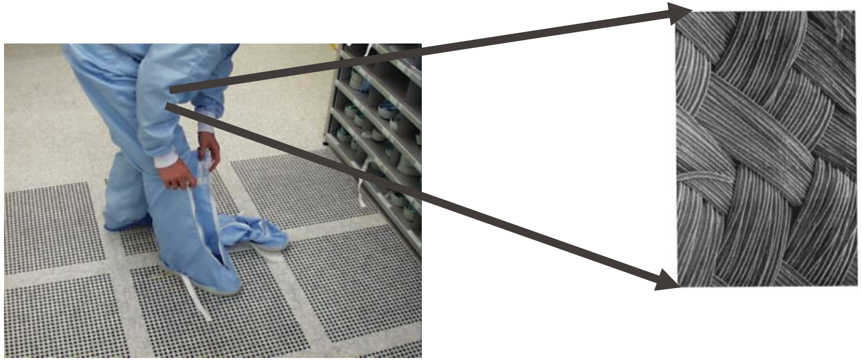


Figure 4.12 Fab area with gowning area, air showers, and service aisles.

Entrée

- Surchausses
- combinaison
- bottes
- masque facial
- gants vynil
- lunettes de sécurité
- carte camipro

Sortie



CMI session

- Z5: Mask fabrication
- Z6: Hamatech HMR900

- PR development
- Cr etching

- Z6: UV exposure
  Süss MA6 Gen3
- Z1: Development
  ACS 200

- Alignement
- Mask for Al etch

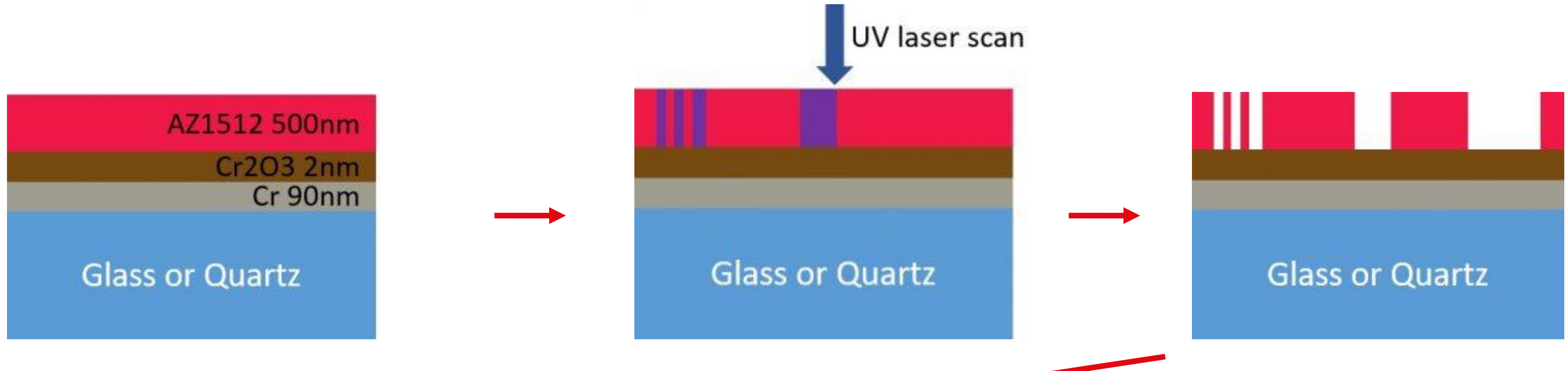
- Z2: Al etching
  Plade Metal
- Z2: Resist stripping
  Bain remover 1165

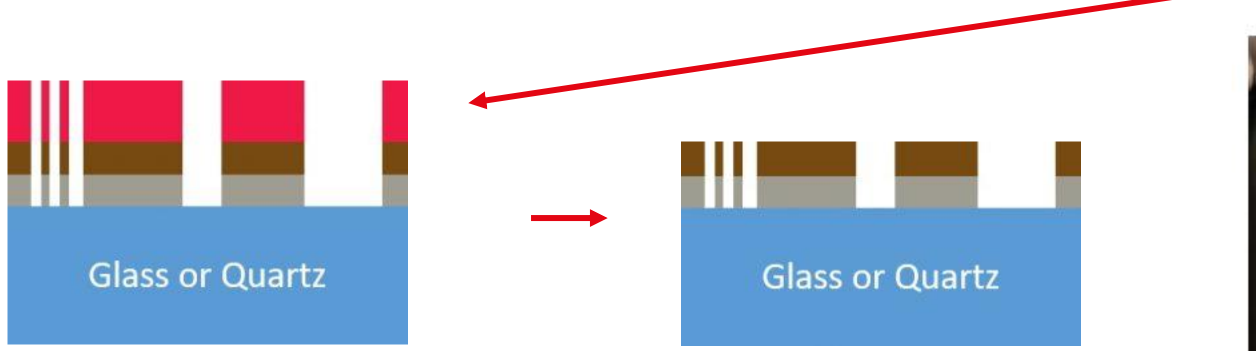
- Al etch
- Resist stripping

- Alpha step
- Z15: Dek Tak

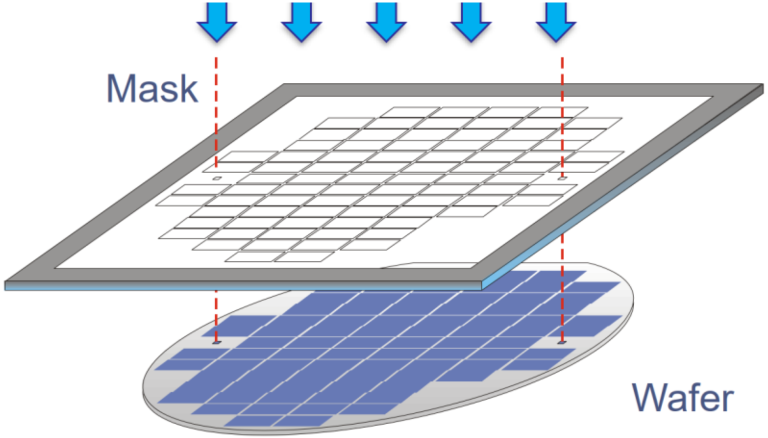
- Al thickness measurement

Fabrication de photomasque

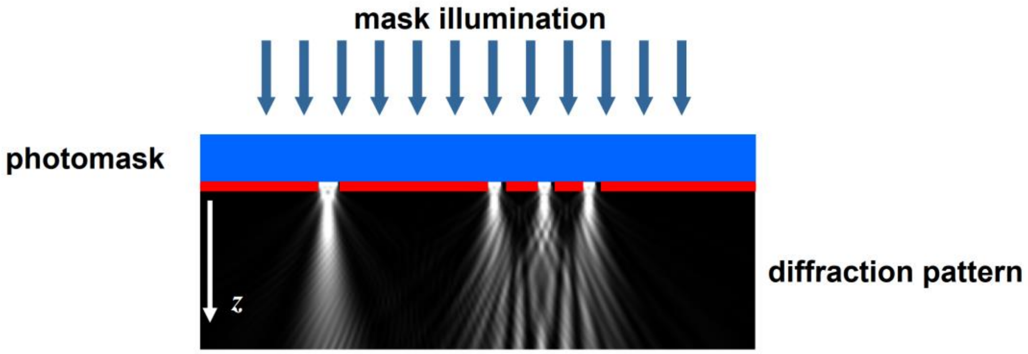


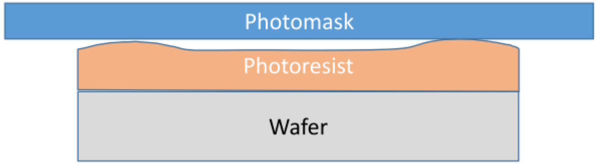


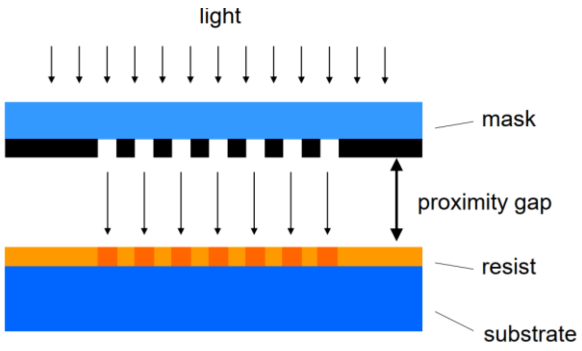
Préparation du masque

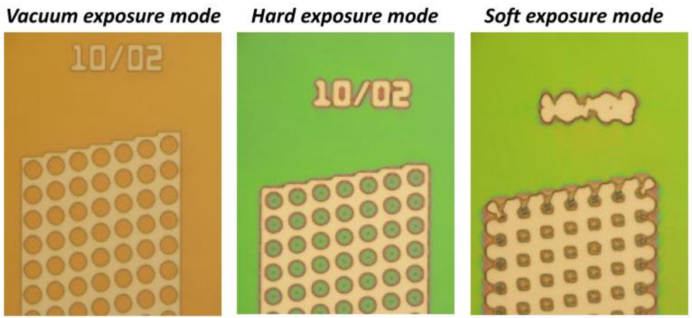


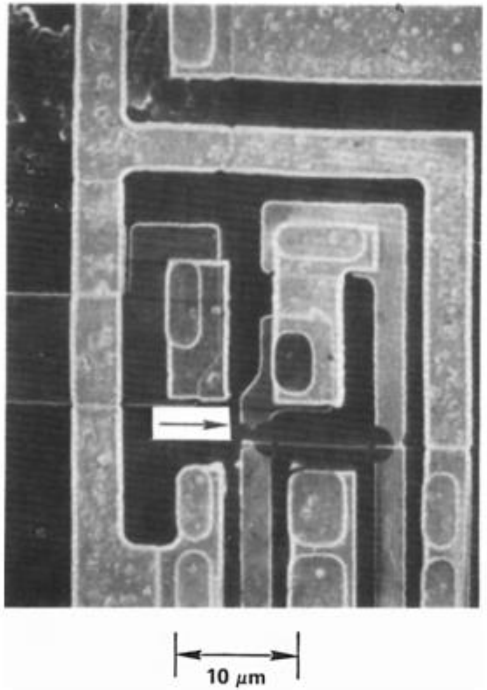
Techniques d'exposition aux UV

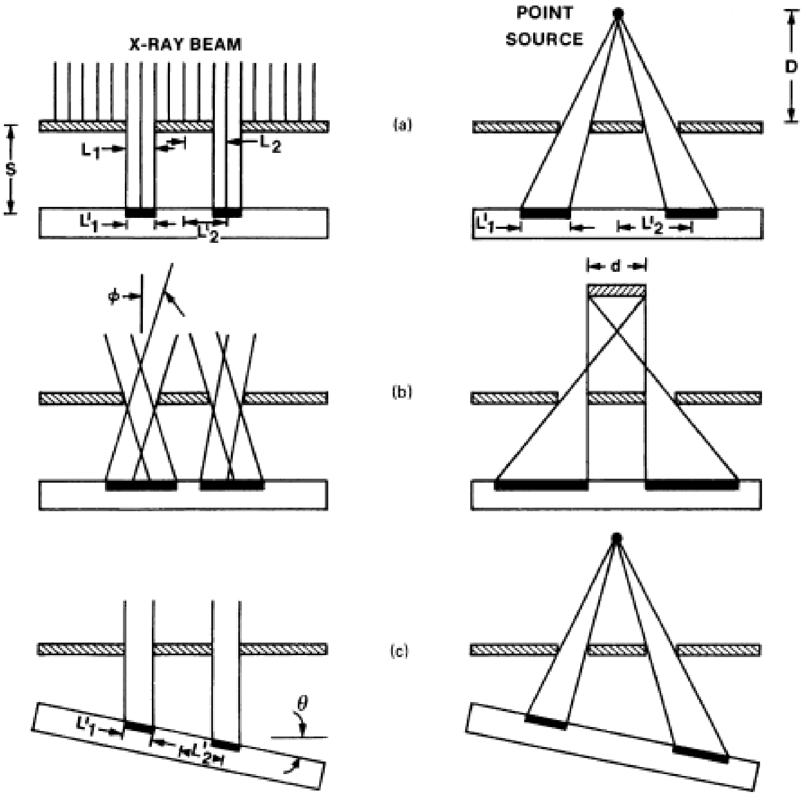






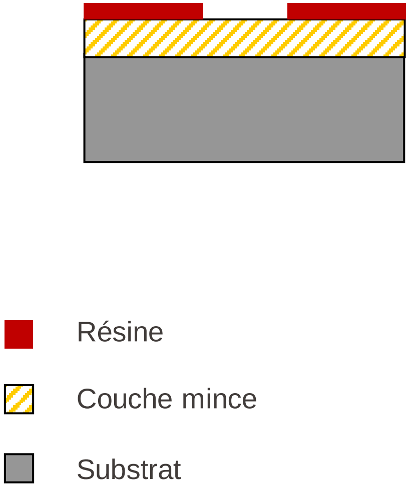



10 μm

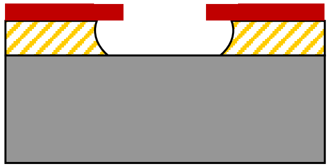

X-RAY BEAM
S
L1
L2
L'1
L'2
POINT
SOURCE
D
(a)
ϕ
d
(b)
(c)
θ

Structuration

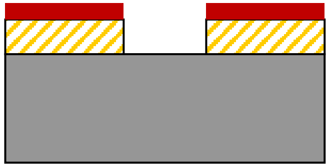
- Masque en résine photosensible



- Gravure chimique
  - Gravure humide
  - Gravure sèche



Gravure isotrope



Gravure anisotrope

Gravure chimique d'aluminium

Chemical product: **ANP** T=35 °C ER= 300 nm/min

$H_3PO_4 : HNO_3 : CH_3COOH : H_2O$ = 73 %: 3.1 % : 3.3 % : 20.6 %

ratio in volume (83:5.5:5.5)

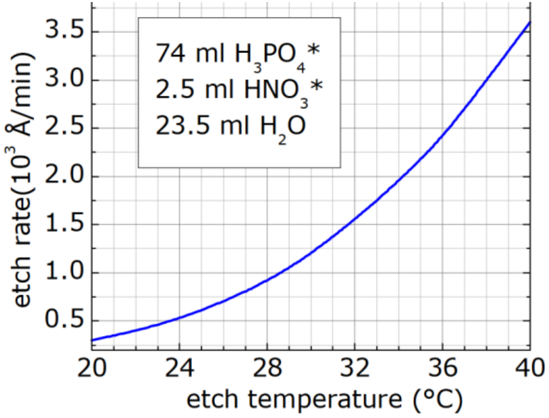
https://cmi.epfl.ch/organisation/materials.php

Typical Aluminium etchants contain mixtures of 1-5 % HNO_3* (for Al oxidation), 65-75 % H_3PO_4* (to dissolve the Al_2O_3), 5-10 % CH_3COOH* (for wetting and buffering) and H_2O dilution to define the etch rate at given temperature.

$$6H^+ + 2Al \rightarrow 3H_2 + 2Al^{3+}$$

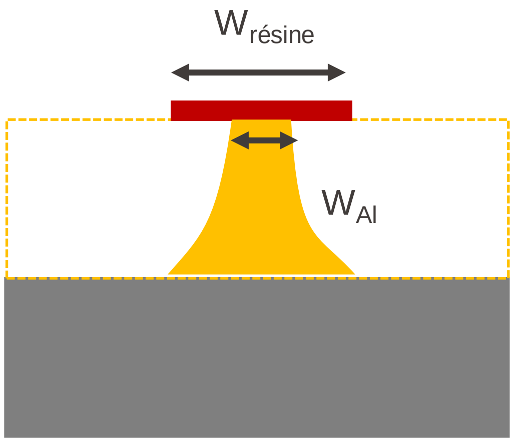
Al^{3+} is water-soluble

- Aluminum etches in water, phosphoric, nitric and acetic acid mixtures.
- Converts Al to Al_2O_3 with nitric acid (evolves H_2).
- Dissolve Al_2O_3 in phosphoric acid.
- Gas evolution leading to bubbles.
- Local etch rate goes down where bubble is formed, leading to non-uniformity.

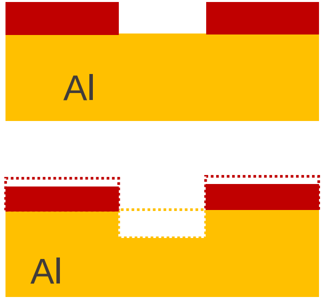


EPFL

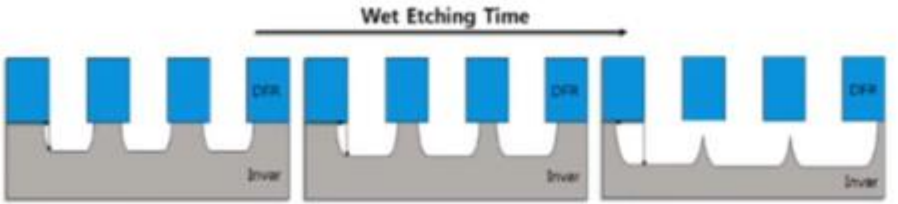
Gravure chimique d'aluminium

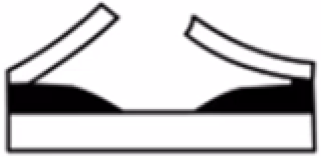


$$V_l = \frac{W_{ré\sin e} - W_{Al}}{2 * T_{gravure}}$$



$$Selectivité = \frac{vitesse \text{ de gravure d'Al}}{\text{vitesse de gravure du résine}}$$

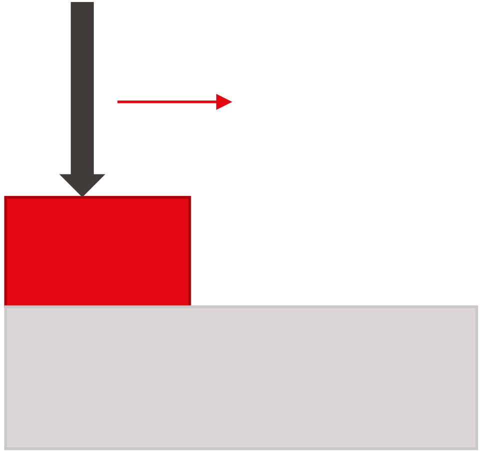


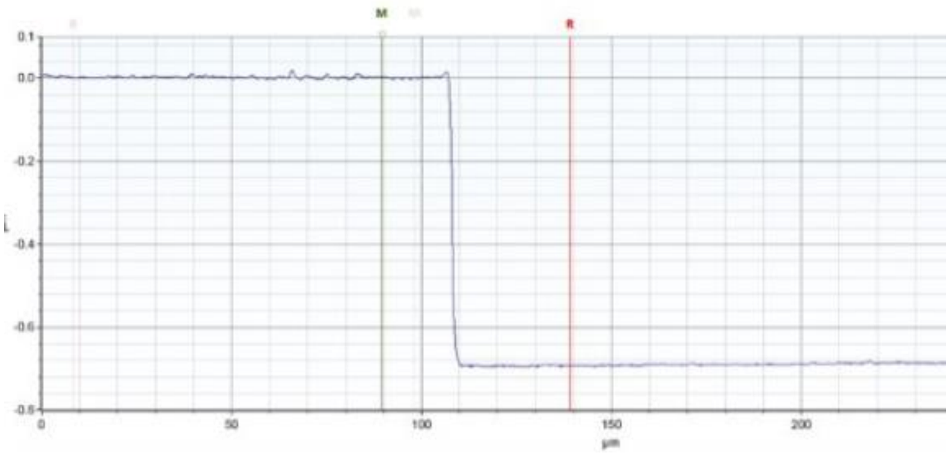


Over Etch and Resist Lifting

Mesure d'épaisseur: profilomètre mécanique

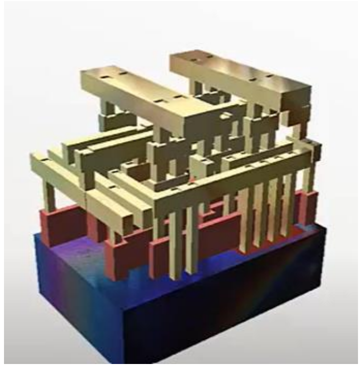
La mesure se fait grâce à une pointe très fine en diamant se déplaçant sur une marche de la couche d'aluminium.

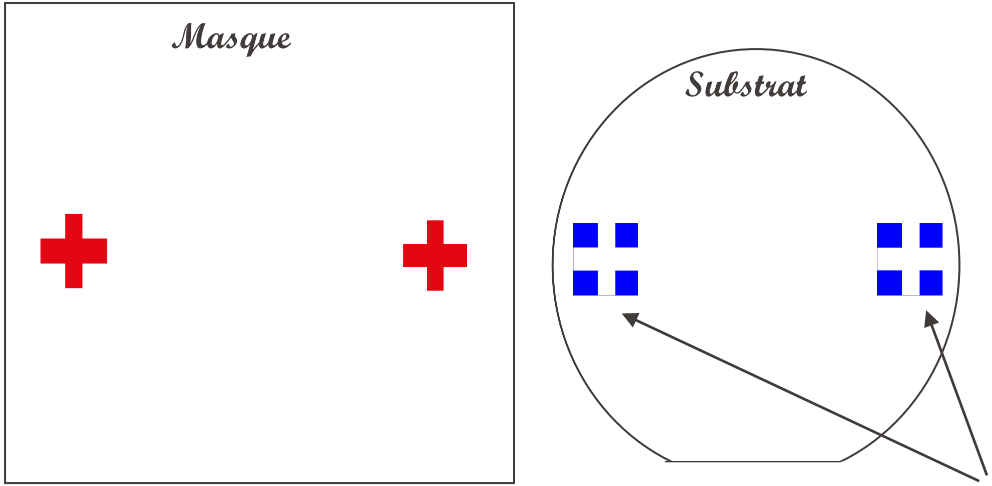




Procédé d'alignement

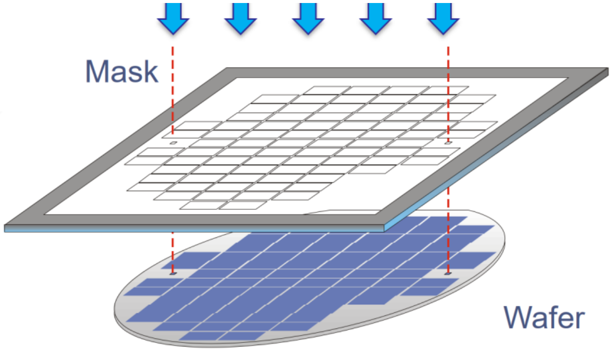
Nécessaire d'aligner le masque et le substrat afin que les motifs soient situés à l'endroit voulu.



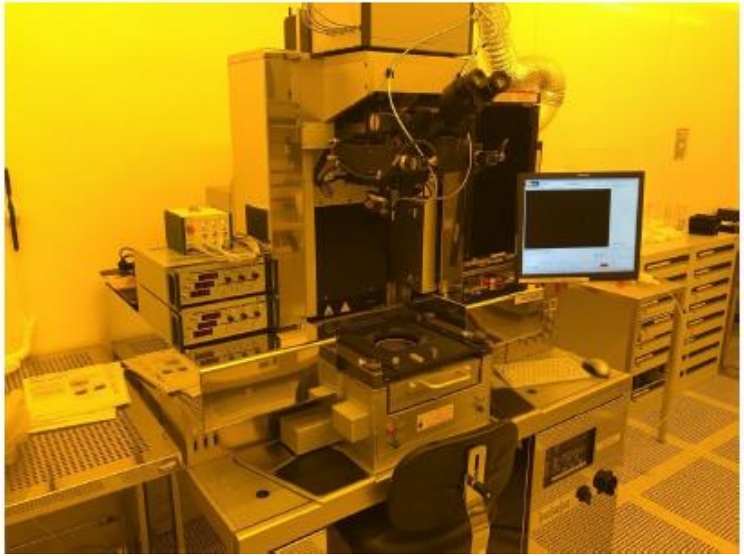


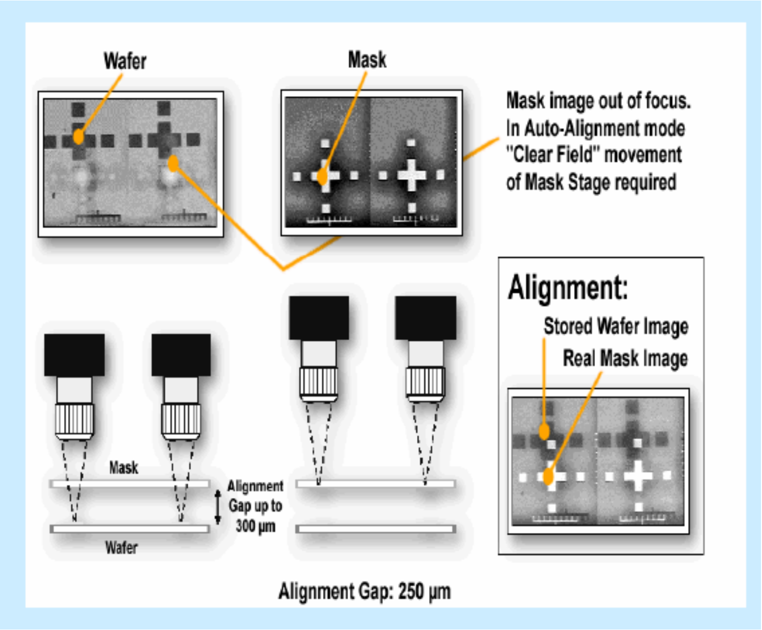
Masque pour le niveau à réaliser

Marques d'alignement de l'étape précédente



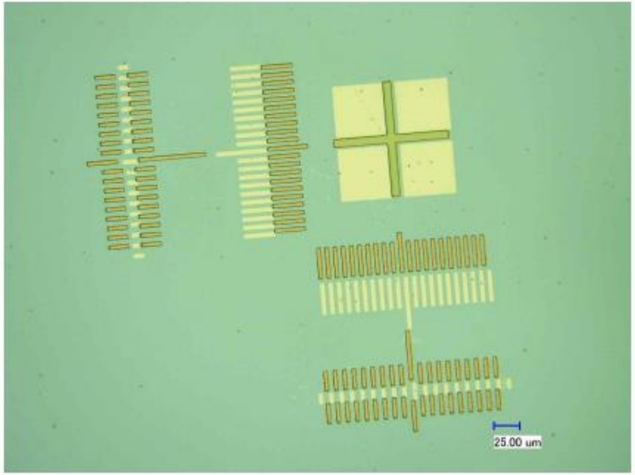
Alignement de masque

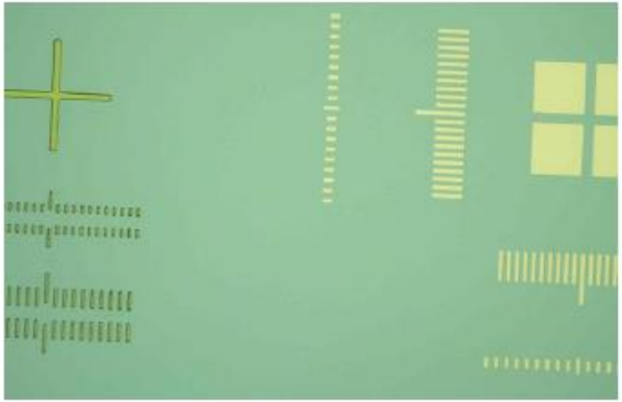


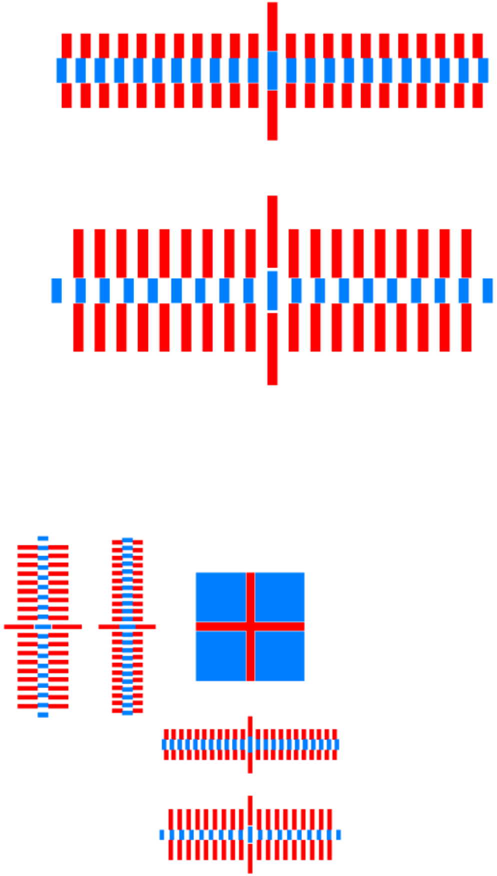


Topic 5 :
mesure électrique
mesure optique

BM3 229/ BM3 231

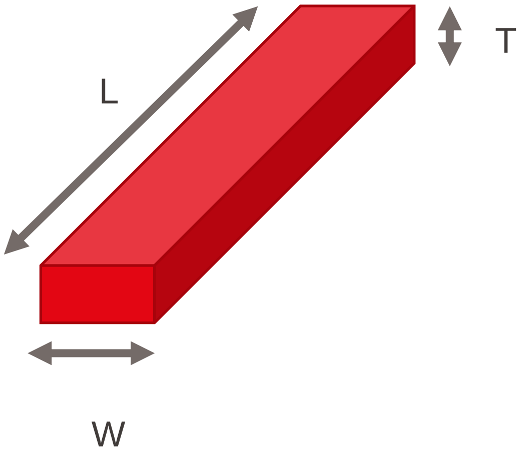






Résistance électrique

Piste de section rectangulaire



$$R = \rho \frac{L}{W.T}$$

$$L = W \longrightarrow R = \frac{\rho}{T} = R_{\blacksquare}$$

$$R = R_{\blacksquare} \frac{L}{W}$$

L (longueur) et W (largeur): caractérisent la géométrie du masque

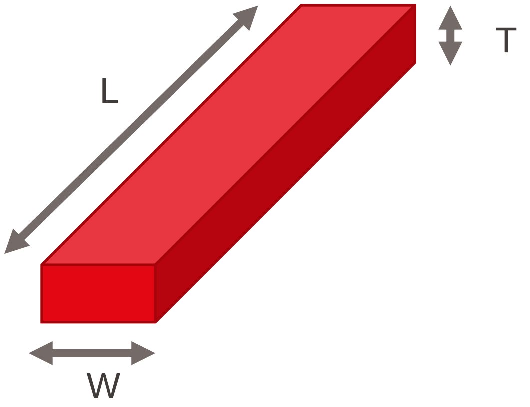
$R_{\blacksquare}$ Résistance par carrée : caractérise la technologie

ρ Résistivité du film

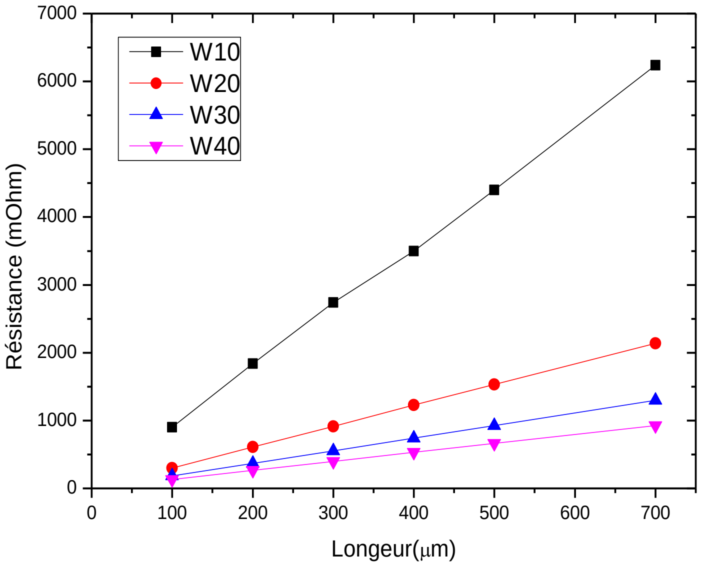
T Epaisseur du film

Résistance électrique: calcul

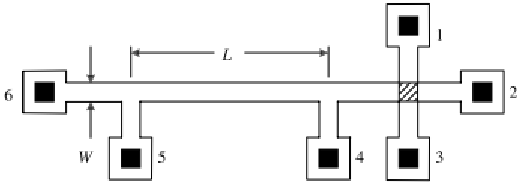
Motif de section rectangulaire



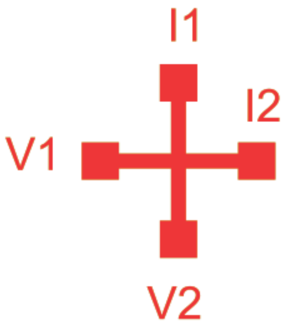
$$R = R_{\blacksquare} \frac{L}{W}$$

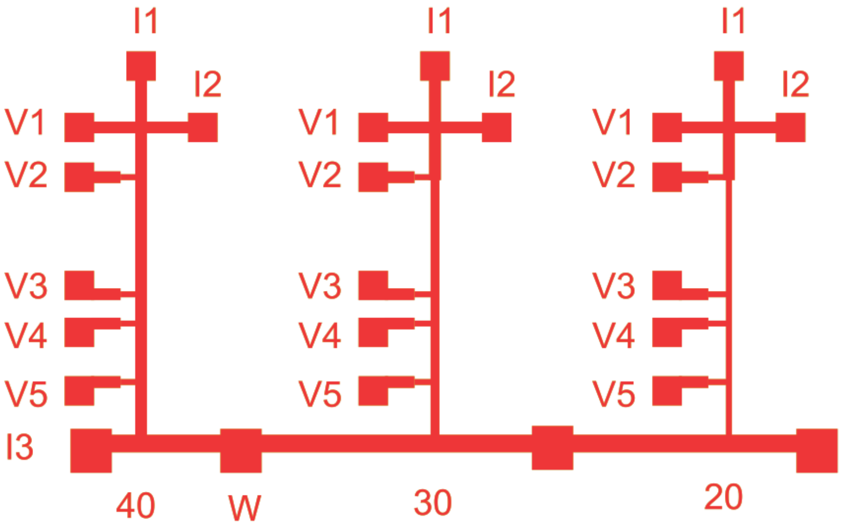


contact	V1-V2	V1-V3	V2-V3	V2-V4	V3-V4	V4-V5	W (unit)
L(µm)	400	750	300	550	200	100	
R(unit)							
R(unit)							
R(unit)							
R(unit)							



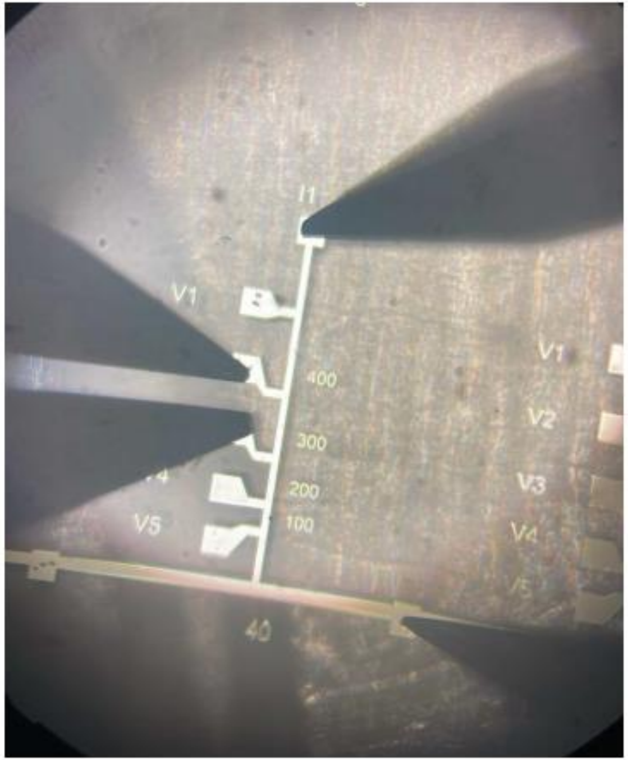
$$R_\blacksquare = R_{sh} = \frac{\pi}{\ln(2)} \frac{V_{34}}{I_{12}} \qquad V_{45} = \frac{R_{sh} L I_{26}}{W}$$





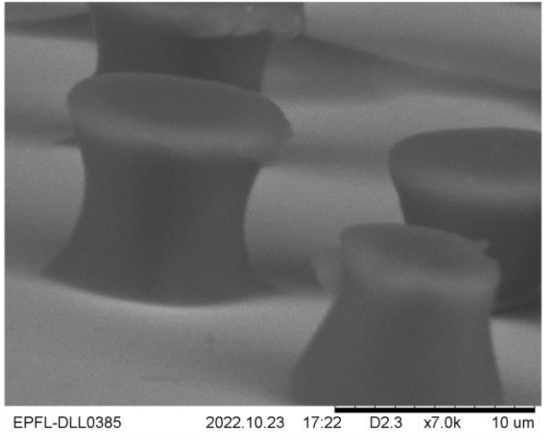
Mesure

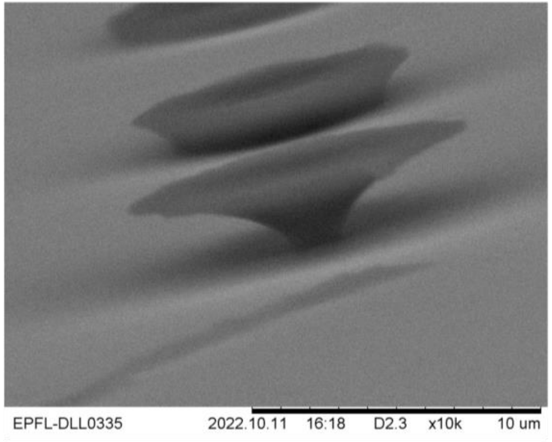
contact	V1-V2	V1-V3	V2-V3	V2-V4	V3-V4	V4-V5	W (unit)
L(µm)	400	750	300	550	200	100	
R(unit)							
R(unit)							
R(unit)							
R(unit)							

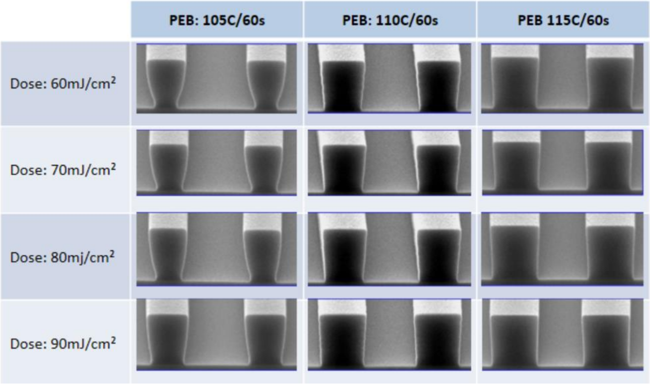


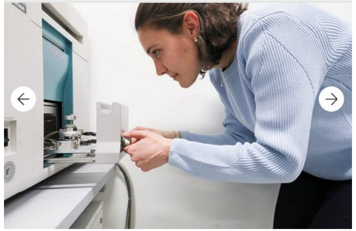
Topic 6 :
Observation profile
Résine négative

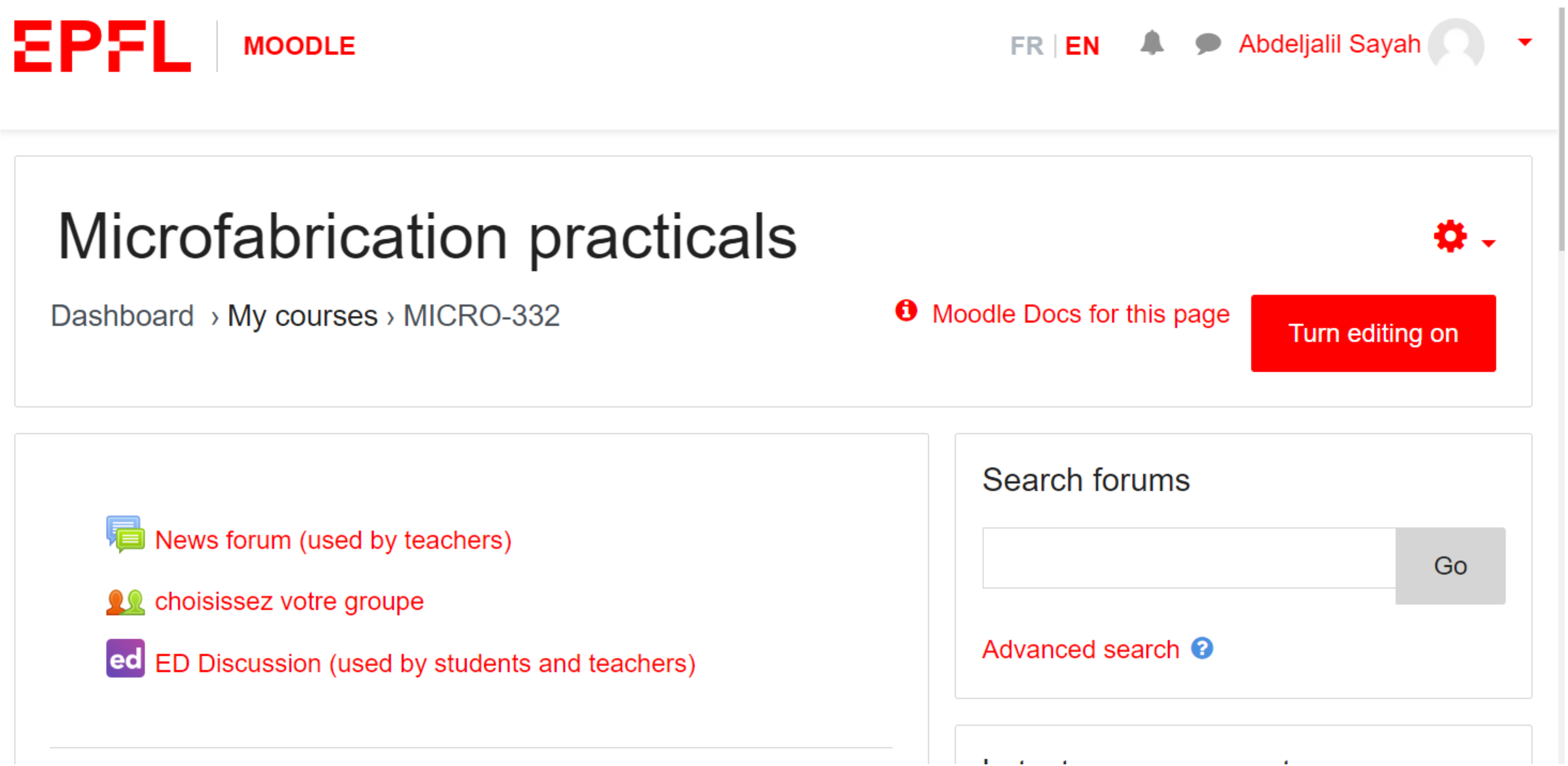
MEB observation







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Microfabrication practicals
Dashboard › My courses › MICRO-332
Moodle Docs for this page
Turn editing on
News forum (used by teachers)
choisissez votre groupe
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ED Discussion (used by students and teachers)
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Advanced search

Sécurité en salle blanche

Centre de microtechnologie, EPFL

Habillement

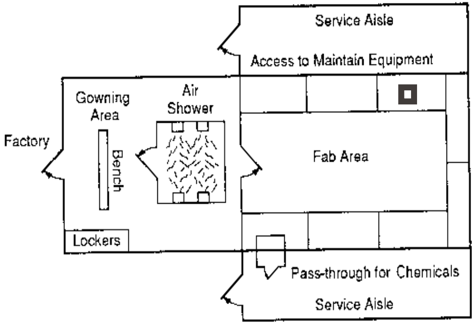
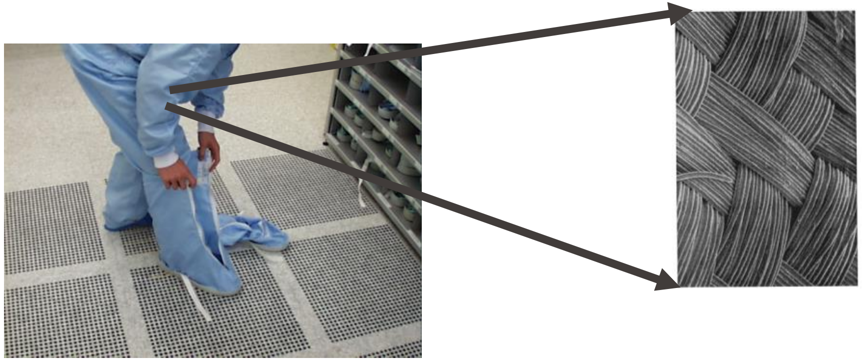


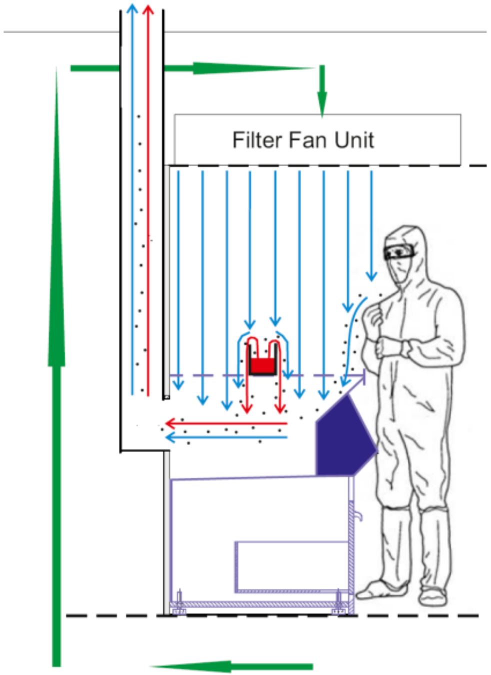
Figure 4.12 Fab area with gowning area, air showers, and service aisles.

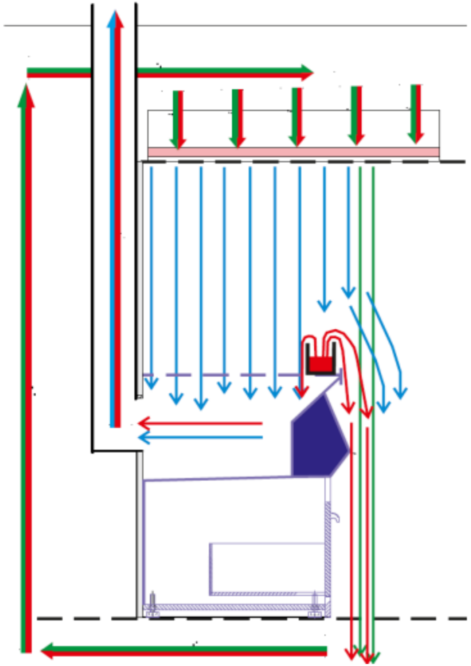
Entrée

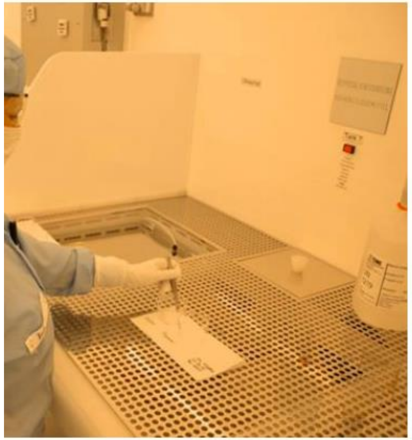
- Surchausses
- combinaison
- bottes
- masque facial
- gants vynil
- lunettes de sécurité
- carte camipro

Sortie

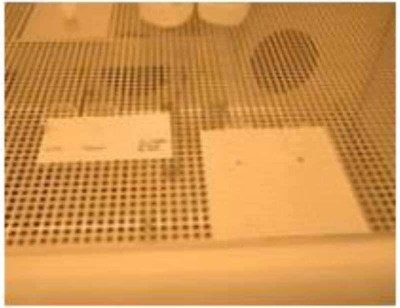


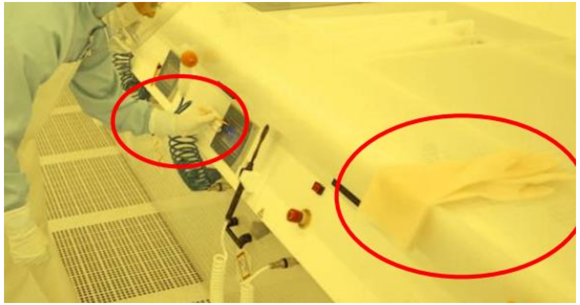

Filter Fan Unit





2. **Do not touch thee knob with fingers that were in contact with chemical.** To press a button, make sure that your glove is clean and dry, and fold you finger like on picture





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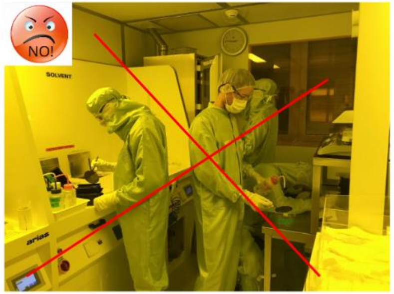
CMi good working practice (Z13 wet-benches)

Before starting your work, make sure to wear a second pair of nitrile gloves, protective glasses and your face-mask!

CMi good working practice **(Z13 wet-benches)**

When working: Do not overcrowd (maximum 2 persons), do not place wafer boxes on the bench, do not use chemicals outside of the bench!



Safety rules

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

115

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

General cleanroom rules

- Lint free cleanroom paper only
- Cleanroom notebooks available through CMi ordering system
- Pens are available in each zone
- Photocopier can be used to transfer notes in and out of the cleanroom
- PC access to public folders in each zone

Prohibited:

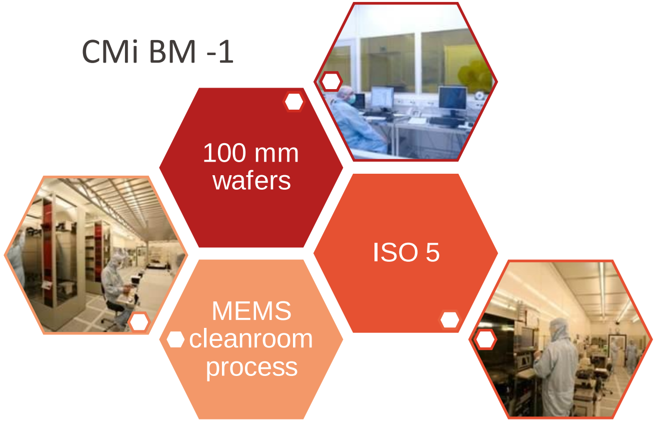
- **normal paper**
- **pencils and normal pens**

- All wafers should be in boxes with :
  - Owner and date labelled
  - Process flow
- All your material should be stored in one red box
- Lost and found shelf
- Wafers must be handled with vacuum or mechanical tweezers

- Do not seat on tables
- Do not scratch your face

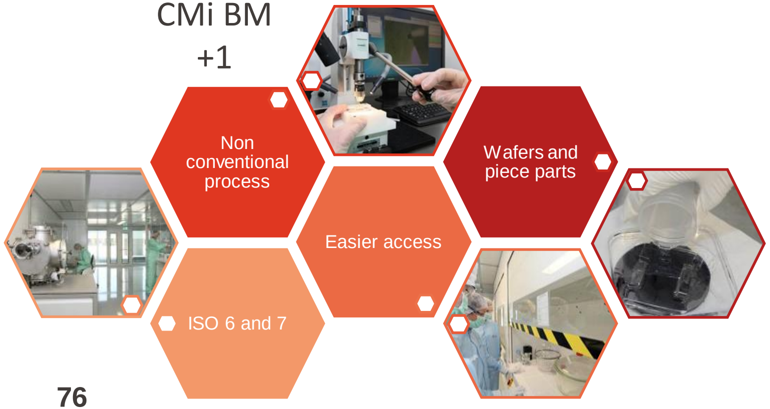
CMi cleanroom concept

CMi BM -1



Ebeam lithography
Photolithography
Etching
Thins films
Metrology

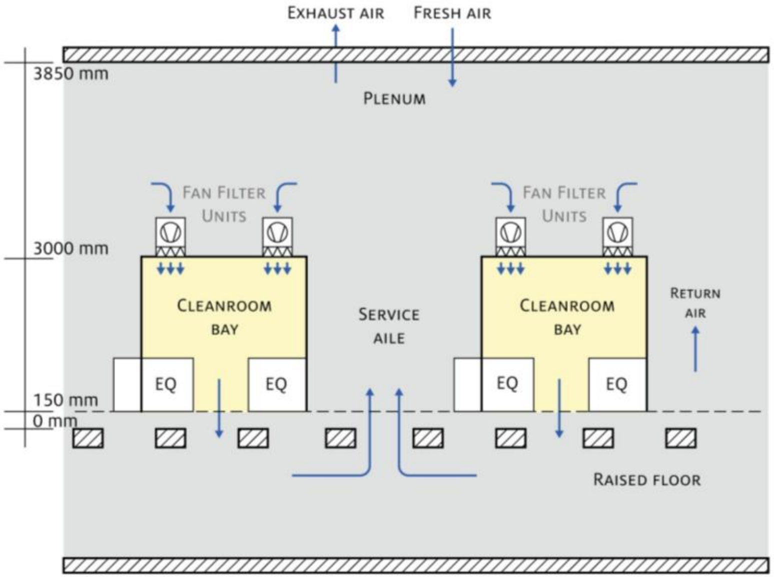
CMi BM
+1



Grinding
Thermal imprint
Inkjet printer
PDMS line
Photolithography on chips
Customized chemistry
Metrology
…

Description of the Cleanroom

Air filtration and circulation in class 100



ACTUAL VALUES (2/3 of maximum capacity)

- 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
  - ISO 5 : 189 units
  - ISO 6 and 7 : 46 units
  - 0.7 m^2 active area
  - total: 189'000 m^3/h
  - filter efficiency : 99.999% for
  - particles size 0.1-0.3 µm

CMi cleanroom concept

Standard ISO 14644-1

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

	Classe ISO	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm	Classe US FS209
	ISO 1	10	2	0	0	0	0	
	ISO 2	100	24	10	4	0	0	
	ISO 3	1 000	237	102	35	8	0	**1**
	ISO 4	10 000	2 370	1 020	352	83	0	**10**
CMi BM -1 ⇒	**ISO 5**	100 000	23 700	10 200	3 520	832	29	**100**
CMi BM +1	**ISO 6**	1 000 000	237 000	102 000	35 200	8 320	293	**1 000**
CMi BM +1	**ISO 7**	∞	∞	∞	352 000	83 200	2 930	**10 000**
	ISO 8	∞	∞	∞	3 520 000	832 000	29 300	**100 000**
	ISO 9	∞	∞	∞	35 200 000	8 320 000	293 000	