

Process management in an academic laboratory: recipe library, data access, monitoring, different tools to be implemented

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- Context
 - LAAS Micro & nanotechnologies platform
 - Photolithography Area

- Process management
 - Photolithography Standard Process Library
 - Periodic process calibration
 - Shared process list : going further
 - Statistic Process monitoring

LAAS Micro & nanotechnologies platform

- **1600m² cleanroom with 40M€ of equipment**
- **160 projects**, academic & industrial / part of RENATECH Network
- **200+ users** can access it, mostly PhDs & Post-docs



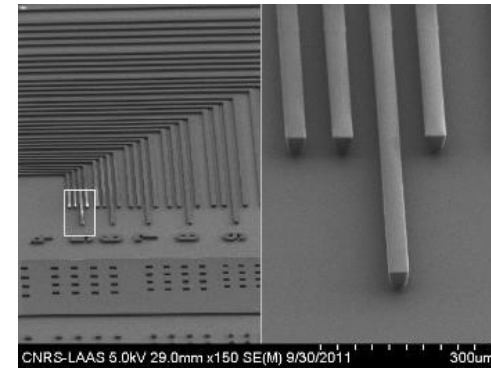
Platform managed by T.E.A.M technical staff
(**27 engineers & technicians**):

bringing support to research teams by managing equipment, developing processes and training users

- PhDs & Post-docs = « work force » in research
- Problem : big turnover = loss of knowledge
- T.E.A.M staff: interaction with users = develop, share and preserve the knowledge
- For 10+ years, we have been applying a quality approach to our working methods

Photolithography Area

- **Open access** after proper training
- Photolithography = essential step in >90% of micro & nano fabrication processes = a cleanroom « hub »



Our strategy : Offer « standard » process recipes

- developed to answer different identified needs
- Checked and calibrated
- Rely on performance, ease of use, safety and reliability from serious, strong suppliers

- **33 « step-by-step » process recipes** developed and tested
- Available **physically** in « process books » and **digitally** on MyFab
- Different recipe categories :
 - Positive resists
 - Negative resists
 - Lift-off resists
 - SU-8s
 - Dry Films

Procédé

[mode opératoire photolithographie ECI3012 1um](#) [info]
[mode opératoire photolithographie ECI3012 2.5um](#) [info]
[mode opératoire photolithographie Nlof 2035 2.5um](#) [info]
[mode opératoire photolithographie Nlof 2035 5um](#) [info]
[mode opératoire photolithographie AZ 40XT 13um](#) [info]
[mode opératoire photolithographie AZ 40XT 20um](#) [info]
[mode opératoire photolithographie AZ 4999 8um](#) [info]
[mode opératoire photolithographie AZ4562 5um](#) [info]
[mode opératoire photolithographie AZ4562 10um](#) [info]
[mode opératoire photolithographie BPN 50um](#) [info]
[mode opératoire photolithographie DF 1005 5um](#) [info]
[mode opératoire photolithographie DF 1020 20um](#) [info]
[mode opératoire photolithographie DF 1050 50um](#) [info]
[mode opératoire photolithographie PHOTEC PH2040 40um](#) [info]
[mode opératoire photolithographie S1805 400nm](#) [info]
[mode opératoire photolithographie SU8 2000.5 800nm](#) [info]
[mode opératoire photolithographie SU8 3005 5um](#) [info]
[mode opératoire photolithographie BARC BarII II 200 200nm](#) [info]
[mode opératoire photolithographie SU8 3025 25um](#) [info]
[mode opératoire photolithographie SU8 3050 50um](#) [info]
[mode opératoire photolithographie SU8 3050 100um](#) [info]
[mode opératoire photolithographie SU8 3050 500um](#) [info]
[mode opératoire photolithographie stripping resist lift off](#) [info]
[mode opératoire photolithographie DF 10100 100um](#) [info]
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[SHARED PROCESS LIST](#) [info]
[mode opératoire photolithographie CPB cd80nm e20nm](#) [info]
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[mode opératoire photolithographie AZ 125nXT 30um](#) [info]
[mode opératoire photolithographie DF SUEX 50um](#) [info]
[mode opératoire photolithographie DF SUEX 100um](#) [info]
[mode opératoire photolithographie DF SUEX 250um](#) [info]
[mode opératoire photolithographie HMDS](#) [info]



■ Recipe example

ECI 3012 <small>POSITIVE</small>		1.1μm	
PREPARATION	<p>The following process parameters are valid for silicon wafer and surface only. Before photolithography : Cleaning, Dehydration, Adhesion promoter (depending on context) On Silicon : Plasma O2 800W 5min (Cleaning + Dehydration) then HDMS (adhesion promoter) Check and Clean your mask before photolithography (AZ 100 Remover bench in Wet process benches)</p>		
COATING	ROT. SPEED (rpm) 3600	ACCELERATION (rpm/s) 4000	TIME (s) 30
			On EVG 120 « enduction ECI 1.1um 4pouces »
BAKE	90°C – 60s		(included in EVG coating recipe)
EBR	<small>OPTIONAL (ONLY IF NECESSARY)</small> ROT. SPEED (rpm) ACCELERATION (rpm/s) TIME (s) 5000 4000 30		On EVG 120 : « détournage classique »
EXPOSURE	EVG 620 <small>(70mW/cm² at 405nm)</small>		3.2 s
	MA 150 <small>LED UV : 90% (6,5mW at 365nm / 13mW at 405nm)</small>		7 s
	MA 6 <small>CH1 : 20mW/cm² at 365nm / 40mW at 405nm</small>		5 s
	MA6 gen4 <small>UV LED (Variable)</small>		200 mJ/cm² (I-line)
PEB	110°C – 60s		
DEVELOPMT	Developer :	MF-CD-26	On EVG 120 : « PEB + Révélation ECI 1.2um 4pouces »
	Duration :	15s (indicative)	
	Rinsing :	eau DI (both sides)	
	<i>Throw away developer directly in the sink</i>		
	Check development level with microscope. Add development time if necessary.		
CONTROL	WAFER BACK SIDE CLEANING with Aceton + DI water MICROSCOPE : check developement & dimensions PROFILOMETER : check resist thickness		

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- Wafer preparation :

PREPARATION

The following process parameters are valid for silicon wafer and surface only.

Before photolithography : Cleaning, Dehydration, Adhesion promoter (depending on context)

On Silicon : Plasma O₂ 800W 5min (Cleaning + Dehydration) then HDMS (adhesion promoter)

Check and Clean your mask before photolithography (AZ 100 Remover bench in Wet process benches)

- Coating & softbake :

COATING	ROT. SPEED(rpm)	ACCELERATION (rpm/s)	TIME (s)
	3600	4000	30
BAKE	90°C – 60s		

■ Exposure :

EXPOSURE	EVG 620 <i>(70mW/cm² at 405nm)</i>	3.2 s
	MA 150 <i>LED UV : 90% (6,5mW at 365nm / 13mW at 405nm)</i>	7 s
	MA 6 <i>CH1 : 20mW/cm² at 365nm / 40mW at 405nm</i>	5 s
	MA6 gen4 <i>UV LED (Variable)</i>	200 mJ/cm² (I-line)

- Post Exposure Bake & Development :

PEB	110°C – 60s
DEVELOPEMNT	<p>Developer : MF-CD-26</p> <p>Duration : 15s (indicative)</p> <p>Rinsing : eau DI (both sides)</p> <p style="text-align: center;"><i>Throw away developer directly in the sink</i></p>

- Control operations :

Check development level with microscope. Add development time if necessary.

CONTROL

WAFER BACK SIDE CLEANING with Aceton + DI water

MICROSCOPE : check development & dimensions

PROFILOMETER : check resist thickness

Periodic process calibration

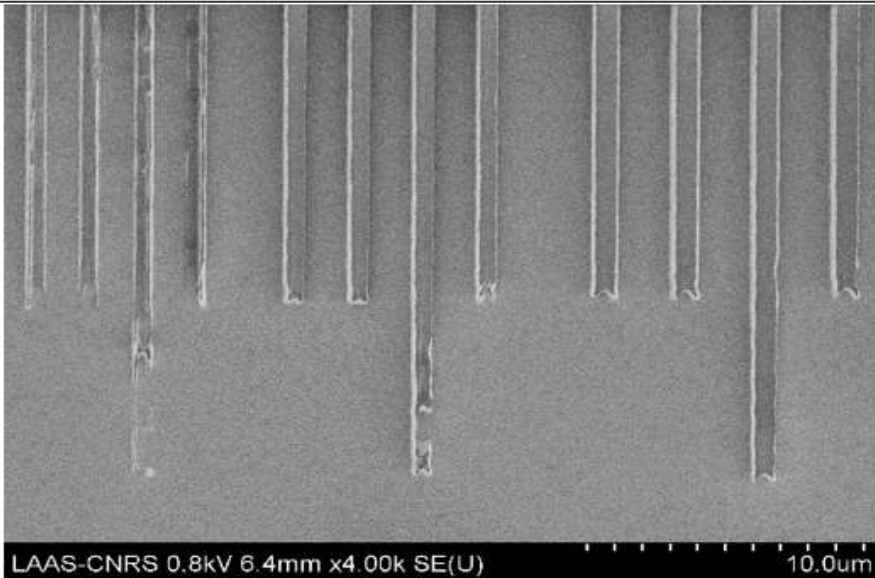
- Periodic check on 3 most commonly used recipe
 - Resist average thickness & uniformity (mechanical profilometer)
 - Resolution & critical dimensions (optical microscope)
 - Resist profiles verticality (SEM)

Periodic process calibration

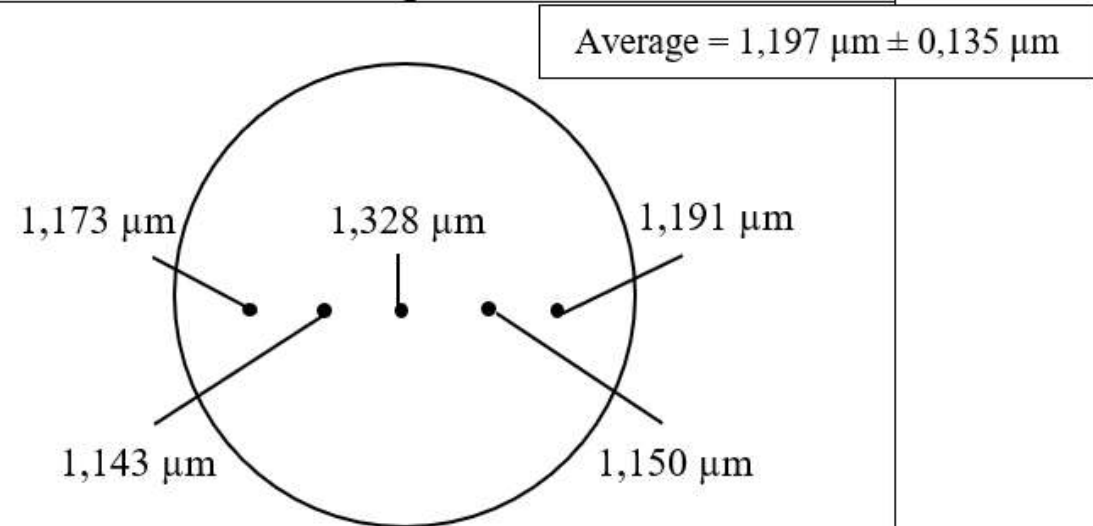
ECI 3012 1,1 μm (resolution: 1,2 μm) :

1. Plasma O₂ (Diener 1000 ml/min, 800 W, 5 min) on silicon SiP 525 μm
2. HMDS auto prog 1
3. Coating and soft-bake with EVG120 recipe: coating ECI 1.1 μm 4pouces
4. Exposure with MA6-Gen4 using mask E059 (I-line 37%, 200mJ/cm², VC)
5. PEB and development with EVG120 recipe: PEB + development ECI 1.1 μm 4p CD
6. Characterization with optical microscope, mechanical profilometer and SEM

SEM S-4800



Mechanical profilometer



Observation : lines shrinking : 0,8 μm instead of 1,2 μm → *Process in accordance with expectations*

Shared process list : going further

- A shared excel table open to all users
- Gather process data and parameters
- Save time while developing a new recipe

PHOTOLITHOGRAPHY ALTERNATIVE PROCESS LIST														
splncoater	coating			soft bake		exposure				PEB		Developpement		Comments
	speed	acc	time	temp	time	machline	GHI line	Dose	contact	temp	time	dev	time	
tournette 1	2300	4000	30	105	1min	MA6 gen1	GHI	70mJ @365	lo vac	105	1min	su8 dev	1min	sur wafer verre
tournette 1	1200	4000	30	95	7min	MA6 gen1	GHI	70mJ @365	VC	95	3min	su8 dev	2min	
tournette 1	1000	1000	30	110	3min	MA6 gen1	GHI	280mJ @365	soft contact	110	3min	MFCD26	4min	hardbake 120°C pdt 1min
tournette 1	2000	4000	30	110	5min	MA6gen4	I	150	VC	110	2min	su8 dev	3min	
tournette 1	3200	4000	30	110	5min	MA6 gen4	I	120	VC	110	2min	su8 dev	3min	
tournette 1	950	4000	30	110	10min	MA6 gen1	GHI	7s/140mJ 365	HC	110	3mn	su8 dev	5min	
tournette 1	2000	4000	30	110	2 min	MA150	GHI	45s/292mJ	VC	120	1min	MFCD26 (EVG120)	100s	4min30 dev if done by hand
tournette 2	3000	4000	30	110	2 min	MA150	GHI	38s/250mJ	VC	120	1min	MFCD26 (EVG120)	200s	3µm resolution
tournette 1	5000	4000	30	110	5min	MA150	I	35s	HC	110	2min	su8 dev	3min	
tournette 1	3000	4000	30	95	4min	MA gen 1	CH1	3.7s	HC	95	3min	su8 dev	3/4min	Rinsolation pleine plaque après développement pendant 5min puis plasma O2 avant hard bake 110°C avec montée en température (prgm 10 plaque SU8 2)
Spray coater	Recette NLOF-5µm			110	4min	MA gen 1	CH1	9s	HC	110	4min	MFCD26	3 à 4min	Puis plasma O2 200W 4min avant métallisation Ti/Au 50/300nm (EVA600)
tournette 1	5000	4000	30	105	1min	MA gen 1	CH2	2.5s	HC	110	1min	MFCD26	40s + 40s	Puis plasma O2 200W 2min avant métallisation Ti/Au 50/300nm (EVA600)
lamination	50°C	2.5bar	1u/min	Penser à enlever les films protecteurs sur les deux faces que l'on souhaite coller avant lamination										
tournette 1	7000	4000	30	110	5min	Ma6 gen4	I	220mJ	HC	110	2min	su8 dev	3min	no hardbake
tournette 2	1200	4000	25	110	1min30s	MA6 gen4	I	400 mJ	vacuum cont	110	2min	su8 dev	3min	stapes pour obtenir une meilleure uniformité
Shipley	70 °C - 2.5 bar - 0.5m/min			-	-	MA6 Gen4	GHI	180mJ	soft contact	-	-	-	-	ne de protection avec la découpe des verres
Shipley	100°C - 2.5 bar - 0.5m/min			-	-	MA6 Gen4	GHI line	375 mJ	soft contact	100°C	8min	cyclohexanone	35 min (2 bains)	
Shipley	65°C - 2 bar - 1m/min			-	-	MA6gen4	GHI line	255 mJ	soft contact	100°C	3 min	cyclohexanone	5 min	
Shipley	100°C - 2.5 bar - 0.5m/min			-	-	MA6	CH1	9 s	soft contact	100 °C	3 min	cyclohexanone	3 min	
Shipley	100 °C - 2.5 bar - 0.5m/min			-	-	MA6	CP	32 s	soft contact	100 °C	8 min	cyclohexanone	35 min	
tournette 1	8000	4000	30	prog	2	MA6g4	I	200mJ	HC	prog	8	SU8 dev	5mn	
tournette 1	5900	1000	40	prog	2	ma6g4	I	200mJ	HC	prog	8	SU8 dev	5mn	
tournette 1	5000	4000	30	prog	2	MA6g4	I	200mJ	HC	prog	8	SU8 dev	5mn	
tournette 1	4000	300	30	prog	3	MA6g4	I	200	HC	prog	8			
tournette 1	4300	300	30	prog	2	MA6g4	I	200	HC	prog	8			
tournette 1	2000	2000	30	115	3min	MA6g4	I	550	HC	115	3min	MFCD26	2x 60s	RAPPEL : pause de 35min après expo UV
tournette 1	800	2000	30	115	5min	MA6g4	I	1500	HC	115	5min	MFCD26	3x60s	

- Use MyFab logs to ask users :
 - Which resist ?
 - Which thickness ?

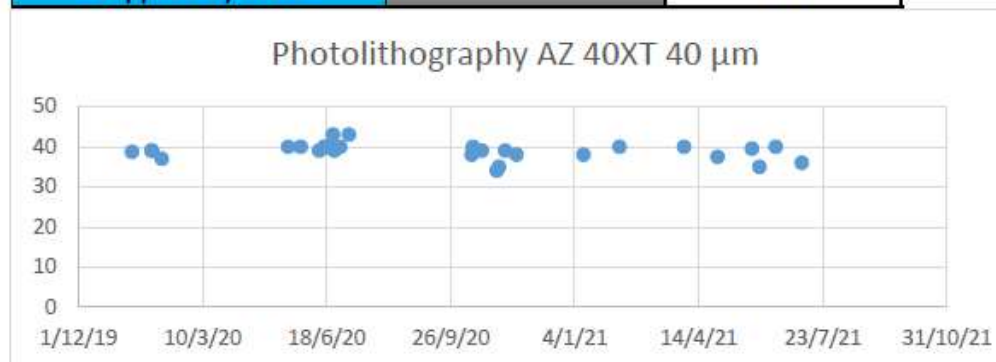
- By gathering that data, it is possible to have statistics on process deviation.

- Downside : relying on users' good will & diligence to be usable

UV Lithography process control

Starting date	6/1/20
Clothing date	19/7/21
Measuring days	560,00
Measures	1665

Photoresists:	Thickness	Measures
ECI 1,1 μm	1,03	485
ECI 2,6 μm	2,43	51
NLOF 2,5 μm	2,39	88
NLOF 5 μm	5,72	108
AZ 40XT 14 μm	13,00	2
AZ 40XT 20 μm	20,27	27
AZ 40XT 40 μm	40,61	41
AZ 15nXT 15 μm	16,40	26
AZ 4562 5 μm	5,28	76
Spraycoating	6,61	29
SU8		164
Dry films		329
Others Resists		97
Supplied by users		142



- Global vision, mutualization & quality approach:
 - Gain time
 - Better results
 - Lower costs

- For the future :
 - Find a better/more reliable way to gather data for statistic control of processes
 - Continue pushing for sharing/saving process parameters & raising awareness among users
 - Exchange with other cleanrooms & platforms to compare our methods ?

Thank you for your attention.

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