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INDUCTIVELY COUPLED PLASMA SYSTEM

Corial 210IL

S/N: **156**

- PROCESSES -

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CONTENT

1 PRINCIPLE OF PROCESS PROGRAMMING 3

1.1 RIE Recipes 4

1.2 ICP Recipes.. 5

1.3 RF and ICP Power Matching 6

2 LASER ENDPOINT DETECTOR.. 7

3 SHUTTLES FOR ETCHING 13

4 HELIUM BACK SIDE COOLING...................................... 15

5 SWITCHING OF PROCESS CHEMISTRIES....................... 17

6 LINER CONFIGURATION 18

6.1 Quartz Liner Configuration 18

7 COOLING PERFORMANCE OF THE CHILLER JULABO 23

8 CONDITIONS TO BE FULFILLED TO RUN A PROCESS...... 24

8.1 Temperature, N2 and Exhaust settings For Dry Roughing Pump....... 24

8.2 TMP Pumping Capacity 24

8.3 Reactor and Load-lock Leak Rates 24

9 PROCESSES WITH WAFER PREHEATING BY PLASMA 25

10 PLASMA ETCHING RECIPES 26

10.1 ICPRIE of SiN: "A_SiN_WF200" Recipe...................................... 27

10.2 ICPRIE of SiO2: "A_SiO2_WF200" Recipe.................................. 30

11 PLASMA CLEANING RECIPES... 32

11.1 Plasma Cleaning: "B_CLEAN_WF200" Recipe 32

1 PRINCIPLE OF PROCESS PROGRAMMING

General description of process programming is given in CORTEX user manual (accessible via Help/Cortex Corial Help/Recipes & Process Settings).

The first steps of any process are needed to get plasma ignition (RIE plasma) and to ensure highly repeatable processes. CORIAL matching boxes perform automatic matching using the LOAD capacitor by default. The TUNE capacitor is either set at the matching position or the RampTo function can also be used for the best tuning.

Note. Selection of regulation of LOAD or TUNE is done in Tool settings: *System/PM1/RF/MB1 Regulation Capacitor Used*:

RF
- Match Box Switch Delay
- MB Default Cap Position Tolerance
- MB Default Cap Position Tolerance Timeout
- MB1 Maximum Capacitors Position
- MB1 Regulation Capacitor Used

PM1/RF/MB1 Regulation Capacitor Used

Value: Load / Tune

Figure 1 Selection of regulation LOAD or TUNE

To ensure plasma ignition, the preset positions of LOAD and TUNE capacitors in the step prior plasma ignition are not at the matching point. The LOAD and TUNE positions allowing minimum reflected RF power are determined and set in the recipe for each process step by using the "Interactive" mode and setting 'PM1 RF AMN Control Mode' to Manual.

Control Parameter	Setpoint	Actual	New Setpoint
PM1 RF AMN Control Mode	Manual	Manual	Automatic

Figure 2 Selection Control mode in 'Interactive'

The matching position is found by either increasing the LOAD capacitor and decreasing the TUNE capacitor or vice versa after ignition of plasma.

WARNING

The RF reflected power cannot be > 50 W for more than 3 s during ignition steps

1.1 RIE Recipes

The recipe has a minimum of 7 steps to establish smoothly the process conditions:		
Step 1	Initial	Pump down the chamber to the set base pressure and to set the temperature of the process.
Step 2	Stabilization	Set the machine parameters (gas flow rates, working pressure) prior starting next process steps. To facilitate the plasma ignition (13.56 MHz), the working pressure is set according to the process (minimum value for plasma ignition = 10 mT), the RF LOAD is set 10% below the RF LOAD matching position and the RF TUNE is set 10 % above the RF Tune position in this step 2. The AMN mode of RF matchbox is in Manual.
Step 3	RF ON	3 sec to ignite the RIE plasma, the RF power is set at 100 W (Corial 200 series) or 200 W (Corial 300 series) for 3 s. The ramping setting, in the windows *Details*, is selected to get the LOAD and TUNE capacitors ramping to the matching position. The RF reflected power cannot be > 50 W during more than 3 s for the ignition step.
Step 4	Go To Etching (OPTIONAL)	5 to 10 s may be needed to go smoothly to etching conditions, particularly, when high RF power is used. In such a case, the ramping setting is selected for RF power, LOAD and TUNE to ensure minimum reflected RF power during this step.
Step 5	Etching	Duration is selected according to the application. Endpoint can be used also for process duration control (ref to EndpointWorks III). This step uses auto-match function (AMN mode in Automatic or Man->Auto) to continuously minimize the reflected RF power.
Step 6	Purge	10 sec are set to purge process gases with O_2, N_2 or Ar.
Step 7	End	10 sec to pump the reactor without any gas.

1.2 ICP Recipes

The recipe has a minimum of 8 steps to establish smoothly the process conditions:		
Step 1	Initial	*Same than RIE process*
Step 2	Stabilization	Set the machine parameters (gas flow rates, working pressure) prior starting next process steps. To facilitate the plasma ignition (13.56 MHz), the working pressure is set according to the process (minimum value for plasma ignition = 10 mT), the RF LOAD is set 10% below the RF LOAD matching position and the RF TUNE is set 10 % above the RF Tune position in this step 2. The AMN mode of RF matchbox is in Manual. To facilitate the ICP plasma ignition (2 MHz), the ICP LOAD position is set at 10% below the ICP LOAD matching position and the ICP TUNE is set at the ICP TUNE matching position. The AMN mode of ICP matchbox is in Manual.
Step 3	RF ON	*Same than RIE process*
Step 4	ICP ON	To ignite the ICP plasma the RF plasma must be established first, the ICP power is set at 500 W (Corial 200 series) or 1000 W (Corial 300 series) for 2 s. The ramping setting is selected to get the LOAD capacitor ramping to the ICP matching position. The ramping setting is selected to get the LOAD and TUNE capacitors ramping to the RF matching position. The ICP and RF reflected power cannot be > 50 W during more than 3 s for the ignition step.
Step 5	Go To Etching (OPTIONAL)	5 to 10 s may be needed to go smoothly to etching conditions, particularly, when high RF power is used. In such a case, the ramping setting is selected for RF power, LOAD and TUNE to ensure minimum reflected RF power during this step.
Step 6	Etching	Duration is selected according to the application. Endpoint can be used also for process duration control (ref to EndpointWorks III). This step uses auto-match function (AMN mode in Automatic or Man->Auto) to continuously minimize the reflected RF power.
Step 7	Purge	10 sec are set to purge process gases with O_2, N_2 or Ar.
Step 8	End	10 sec to pump the reactor without any gas.

1.3 RF and ICP Power Matching

Here below basic rules allowing to simplify searching for RF and ICP matching points are given.

ICP MATCHING		
Action on process parameter	**Required action on matching**	
	ICP Tune	**ICP Load**
ICP Fwd Power ↑	↑	↑
Working pressure ↑	↓	↓
Type of gas: electropositive gas (e.g., Ar) → electronegative gas (e.g., O_2, SF_6, Cl_2)	↓	↓
RF MATCHING		
Action on process parameter	**Required action on matching**	
	RF Tune	**RF Load**
RF Fwd Power ↑	↑	↑
Working pressure ↑	↓	↓
Type of gas: electropositive gas (e.g., Ar) → electronegative gas (e.g., O_2, SF_6, Cl_2)	↑	↓
Note: in ICP processes ICP matching must be implemented first, and then RF matching has to be done.		

2 LASER ENDPOINT DETECTOR

Laser endpoint detector (laser interferometer) allow real-time control over deposition/etching rate, thickness/etched depth, and process end pointing.

In the "Step Termination" window of the etching step, select 'Endpoint Detector' and the recipe that you have created in the software EndpointWorks III. It is needed to determine also maximum and minimum time and appearance of an alarm if endpoint detector is unable to process the signal. The refractive index of the material must be programmed also.

Refractive index versus the wavelength is reported in the table 1, the exact value for given films can be determined by ellipsometry. Typical wavelength of the laser diode of the system is 675 nm, exact value can be read on the endpoint detector case.

Wavelength (nm)	**254**	**405**	**436**	**546**	**675**	**905**
Photoresist	/	/	/	/	**1.64**	1.62
Si	1.608	5.42	4.831	4.106	**3.815**	3.67
SiO_2	1.5	1.469	1.466	1.46	**1.455**	1.451
Si_3N_4	2.27	2.07	2.06	2.03	**2.02**	2.005
SiO	2.01	2.12	2.09	2.01	**1.948**	1.913
TiO_2	2.37	3.2	3.0	2.8	**2.6**	2.7
SiC	/	/	/	/	**2.621**	2.592
GaAs	2.89	4.44	5.06	4.07	**3.79**	3.57
GaN	/	/	/	/	**2.36**	2.34
AlN	/	/	/	/	**2.145**	2.131
Sapphire	/	/	/	/	**1.764**	/
Perylene-C	/	/	/	/	**1.64**	/
InP	/	/	/	/	**3.504**	3.047
$Al_{0.2}Ga_{0.8}As$	/	/	/	/	**3.676**	3.455
$Al_{0.4}Ga_{0.6}As$	/	/	/	/	**3.522**	3.301
$Al_{0.6}Ga_{0.4}As$	/	/	/	/	**3.361**	3.177
$Al_{0.8}Ga_{0.2}As$	/	/	/	/	**3.215**	3.097
AlAs	/	/	/	/	**3.213**	3.096

Table 1 Refractive index

Deposition/etching rate, thickness/etched depth during recipe adjustment can be estimated ‘on the fly’ using the relation between the thickness per interferogram period and optical parameters of the film:

$$Period = \frac{\lambda}{2n}$$

where λ: lager wavelength (nm), n: film refractive index.

Material	RI	Wavelength (nm)	Thickness per period (nm)
Photoresist	1.64	675	205.8
Si	3.815	675	88.5
SiO2	1.455	675	232
Si3N4	2.02	675	167.1
SiO	1.948	675	173.3
TiO2	2.6	675	129.8
SiC	2.621	675	128.8
GaAs	3.79	675	89.1
GaN	2.36	675	143
AlN	2.145	675	157.3
Sapphire	1.764	675	191.3
Perylene-C	1.64	675	205.8
InP	3.504	675	96.3
Al0.2Ga0.8As	3.676	675	91.8
Al0.4Ga0.6As	3.522	675	95.8
Al0.6Ga0.4As	3.361	675	100.4
Al0.8Ga0.2As	3.215	675	105
AlAs	3.213	675	105

For measurements make sure that the laser spot is in the middle of the sapphire window. The following adjustment can be needed during the installation of ICP spacer between the vacuum vessel and ICP source.

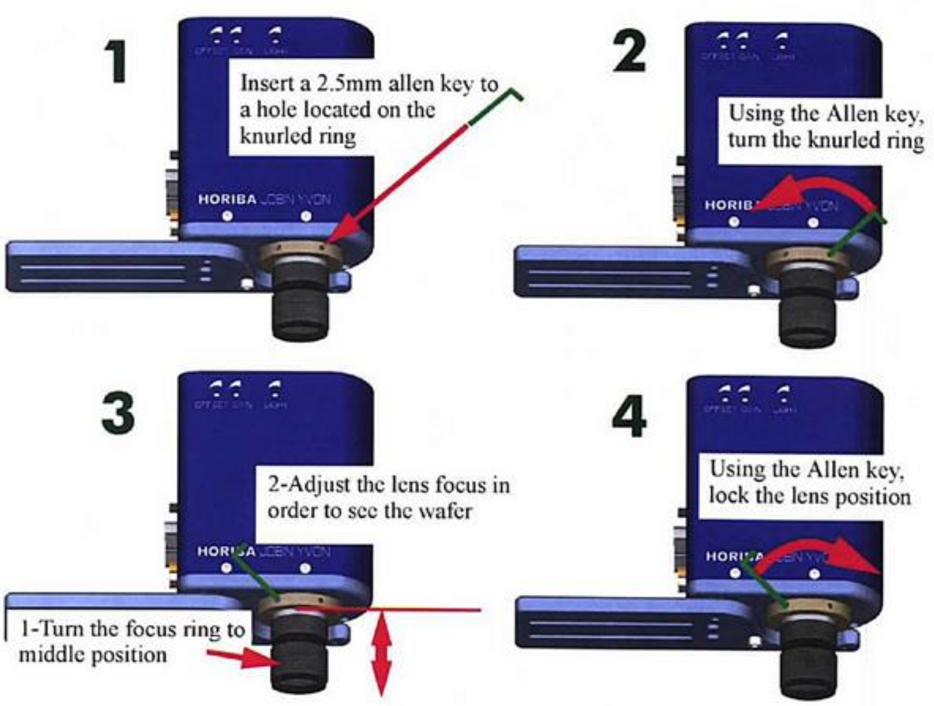
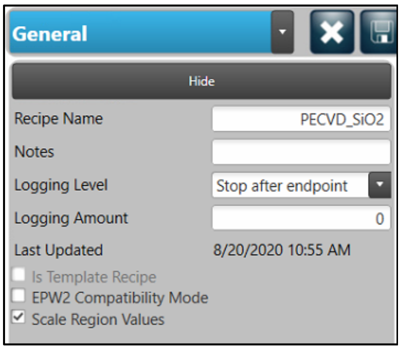


Figure 3 Adjustment steps of the camera

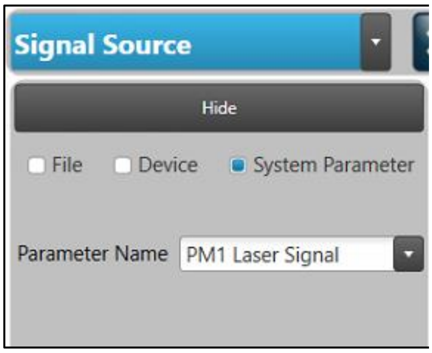
The EndpointWorks III software is used for the endpoint detection. To create a recipe, check that “Signal source” (2) and “Signal Filter” (3) settings are correct as described in (2) and (3) respectively. Next, in the section “Endpoint Detection” (4), select the icon “Thickness” if not open, replace the existing targeted thickness if needed. Do the same with the Refractive Index (RI) while the estimated deposition/etching rate can be set to “0” if this parameter is not known. Save the process. Do not exit the software.

1



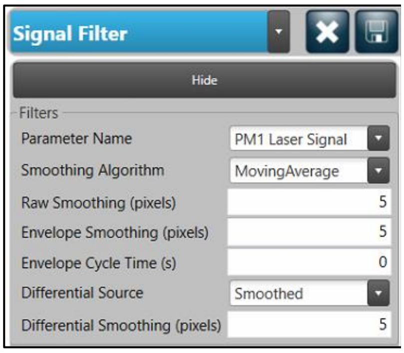
Recipe Name: PECVD_SiO2
Notes:
Logging Level: Stop after endpoint
Logging Amount: 0
Last Updated: 8/20/2020 10:55 AM
☐ Is Template Recipe
☐ EPW2 Compatibility Mode
☑ Scale Region Values

2

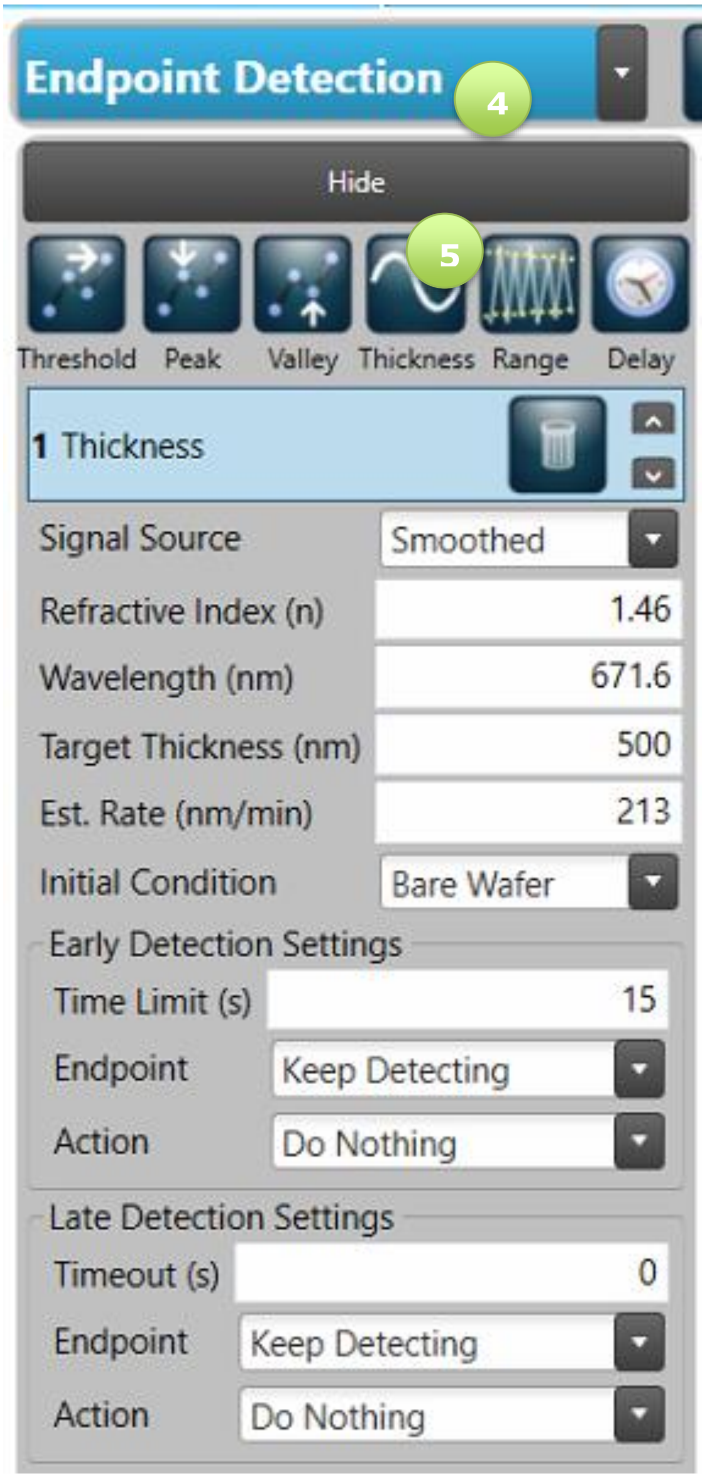


○ File ○ Device ● System Parameter
Parameter Name: PM1 Laser Signal

3



Parameter Name: PM1 Laser Signal
Smoothing Algorithm: MovingAverage
Raw Smoothing (pixels): 5
Envelope Smoothing (pixels): 5
Envelope Cycle Time (s): 0
Differential Source: Smoothed
Differential Smoothing (pixels): 5



1 Thickness

Signal Source: Smoothed
Refractive Index (n): 1.46
Wavelength (nm): 671.6
Target Thickness (nm): 500
Est. Rate (nm/min): 213
Initial Condition: Bare Wafer

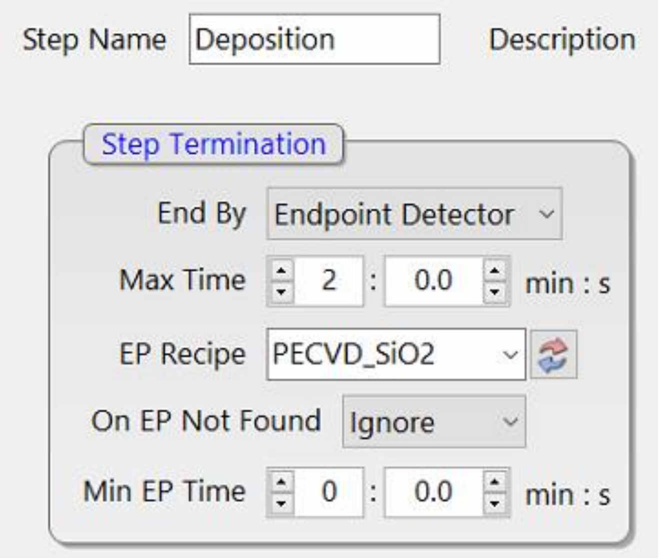
Early Detection Settings
Time Limit (s): 15
Endpoint: Keep Detecting
Action: Do Nothing

Late Detection Settings
Timeout (s): 0
Endpoint: Keep Detecting
Action: Do Nothing

Make sure that the laser spot is in the middle of the gas shower hole.

The typical refractive index versus the wavelength is reported in the previous table.

In the CORTEX software, go in the "Edit Recipe" function, at the step "Etching/Deposition", select "Endpoint Detector" in "end by" line. In "EP Recipe" line, select the name of the recipe saved in the EndpointWorks (see Figure 4).



Step Name: Deposition

Description

Step Termination

End By: Endpoint Detector

Max Time: 2 : 0.0 min : s

EP Recipe: PECVD_SiO2

On EP Not Found: Ignore

Min EP Time: 0 : 0.0 min : s

Figure 4 Cortex settings in "Edit Recipe" for EPD use

3 SHUTTLES FOR ETCHING

Shuttles are selected according to the material to etch. Generally speaking, the quartz shuttle is used for the chlorinated chemistry and the graphite shuttle for the fluorinated one.

⚠ CAUTION

It is not allowed to use graphite shuttle components during Chlorinated processes due to desorption of Chlorine species from graphite after shuttle is out the reactor

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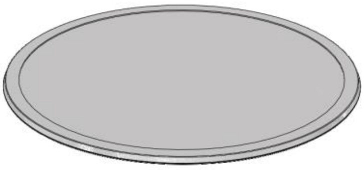
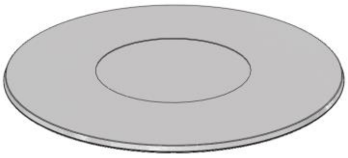
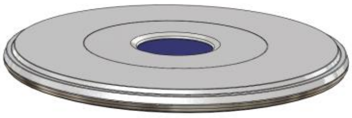
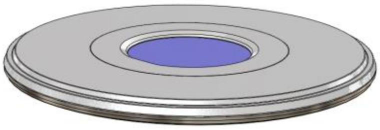
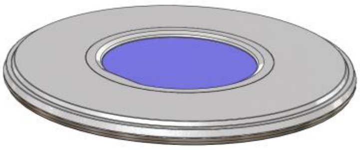
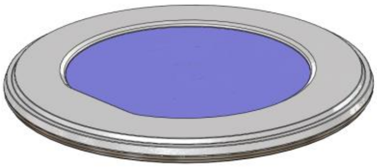
The table below gives the range of use for each type of shuttle.

Shuttle	Picture	Acceptable wafer thickness	Helium Clamp. Pressure	Acceptable temperature
NG20 **1 x 200 mm**		**100 µm to 900 µm**	Clamping pressure with or without substrate $P_{He} > 3$ Torr $P_{He} < 10$ Torr	The shuttle must be used within the temperature range **-20°C to 150°C**
NG20-100 **1 x 100 mm**		**100 µm to 900 µm**	Clamping pressure with or without substrate $P_{He} > 3$ Torr $P_{He} < 10$ Torr	The shuttle must be used within the temperature range **-20°C to 150°C**
NQ200 **1 x 200 mm**		**100 µm to 900 µm**	Clamping pressure with or without substrate $P_{He} > 3$ Torr $P_{He} < 10$ Torr	The shuttle must be used within the temperature range **-20°C to 150°C**
NQ200-100 **1 x 100 mm**		**100 µm to 900 µm**	Clamping pressure with or without substrate $P_{He} > 3$ Torr $P_{He} < 10$ Torr	The shuttle must be used within the temperature range **-20°C to 150°C**
WF50 **1 x 2”**		**250 µm to 450 µm**	Clamping pressure with standard 2” Si wafer PHe > 2 Torr PHe < 10 Torr	The shuttle must be used within the temperature range **-20°C to 150°C**

WF75 **1 x 3”**		**325 µm to 525 µm**	Clamping pressure with standard 3’’ Si wafer PHe > 2 Torr PHe < 10 Torr	The shuttle must be used within the temperature range **-20°C to 150°C**
WF100 **1 x 100mm**		**425 µm to 625 µm**	Clamping pressure with standard 4’’ Si wafer PHe > 2 Torr PHe < 10 Torr	The shuttle must be used within the temperature range **-20°C to 150°C**
WF150 **1 x 150 mm**		**550 µm to 750 µm**	Clamping pressure with standard 150 mm Si wafer PHe > 2 Torr PHe < 10 Torr	The shuttle must be used within the temperature range **-20°C to 150°C**
WF200 **1 x 200 mm**		**650 µm to 850 µm**	Clamping pressure with standard 200 mm Si wafer PHe > 2 Torr PHe < 10 Torr	The shuttle must be used within the temperature range **-20°C to 150°C**

For the shuttle WF50, WF75 and WF100 the central clamping ring can be in graphite or quartz. Graphite clamping ring is recommended for conductive wafers, large PR surface and with fluorine chemistry.

⚠ CAUTION

Wafer sizes must be within the dimension acceptable to avoid any shuttle breakage, or He leak

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4 HELIUM BACK SIDE COOLING

A helium flow is applied at the backside of the shuttle when a process is running.

The helium pressure applied at the backside of shuttle allows thermal exchange between the cathode and the plate or shuttle. The helium pressure leads to cool or heat the shuttle. A helium clamping pressure is > to 3 Torr to allow efficient exchange.

It is mandatory to use helium backside cooling when ICP recipes are used to ensure sufficient thermal exchange between the wafer and the shuttle.

He backside cooling is not mandatory for RIE processes.

The table below describes the adapted He clamping pressure and the He flow associated.

Shuttle	Steps in the recipe	He Clamp. Pressure (Torr)	He flow (sccm)	Process Interlock Stop of process
WF 50 **WF 75** **WF 100** **WF150** **WF200**	All steps	Set to 5 Torr	Reg To 15 sccm	He Clamp. Pressure > 25 Torr
NQ200 **NQ100** **NG20** **NG20-100**	All steps	Set To 5 Torr	Reg To 10 sccm	He Clamp. Pressure > 25 Torr

Please note that Helium clamping pressure is defined as:

He clamping Pressure = He Pressure measured with substrate – He Pressure measured without shuttle.

The figure below gives the He pressure for the shuttles with no wafer for He flow rate within the range from 0 to 50 sccm.

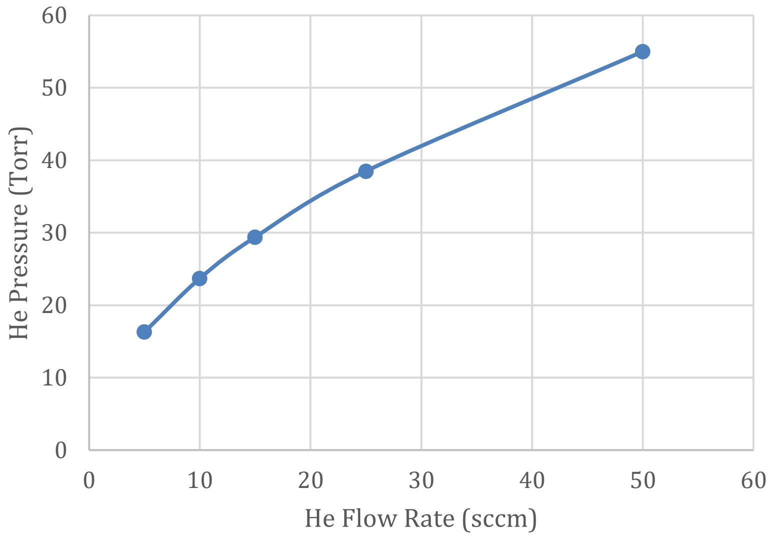


Figure 5 He pressure as function of He flow rate without substrate

5 SWITCHING OF PROCESS CHEMISTRIES

Switching between Fluorinated and Chlorinated process chemistries is possible, certain precautions must be taken to assure reproducibility of processes.

The overall principle is to do a plasma cleaning followed by a conditioning of the reactor with respective process (SiO_2 etching for example if transition to fluorinated gas).

Plasma cleaning is based on an O_2/CHF_3 plasma in ICP-RIE mode of sufficiently long duration (say, 45 minutes). The conditioning process depends on the customer and its application.

Transitioning from chlorinated to fluorinated chemistry recommended steps:

1. Plasma cleaning.
2. Reactor venting for manual cleaning with DI water then IPA may be necessary if the reactor was heavily contaminated. If quartz liner is used in the vacuum vessel, it is recommended to swap the quartz liner and clean the enclosure before putting back the vessel under vacuum.
3. Return to vacuum.
4. Implement plasma cleaning.
5. Implement reactor conditioning.

Conditioning plasma: plasma with the same recipe used for the etching process and the same shuttle. We advise to run a conditioning plasma for 5-10 min for an etching of few minutes of few hours in order to condition the reactor walls.

⚠ WARNING

In some cases (e.g., after running PSS processes) the recovery of etching performances can be achieved after 2 or 3 conditioning processes.

6 LINER CONFIGURATION

6.1 Quartz Liner Configuration

Quartz liner is used to implement sputter-etch processes in ICP configuration. The quartz liner can be used also in processes with high rate of hard mask erosion (such as SiC etching with Ni mask). To proceed, follow the steps described below:

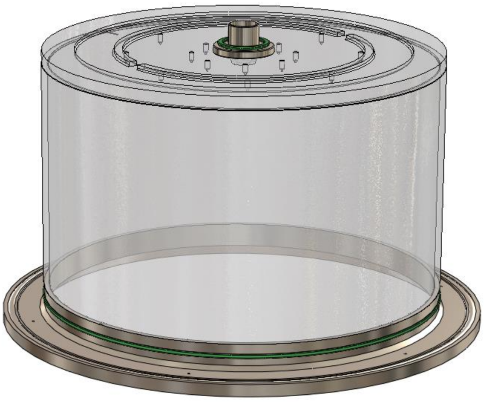


Figure 6 Quartz liner

Quartz liner is used to protect ICP reactor walls from contamination, or to simplify reactor cleaning in case the process is prone to heavy contamination of the reactor. The following liner installations are possible:

1. Disconnect RF cable from ICP matchbox.
2. Remove the top panel of the reactor.
3. Remove the 4 screws of the reactor.
4. Vent the reactor by selecting the chamber in the reactor scheme and by using the button ‘Vent’ in the Windows Service/Vacuum system and open the chamber.
5. Block the ICP reactor in opened position.

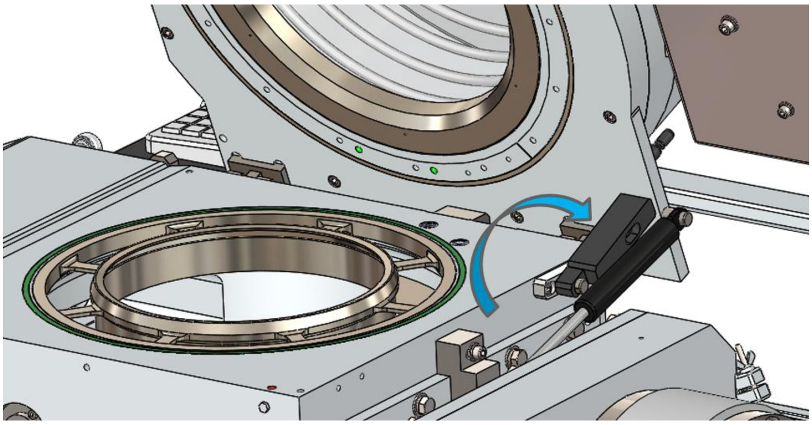


Figure 7 View of ICP reactor open and blocking system

6. Remove the clamping tool then remove the bottom liner by pulling it symmetrically.

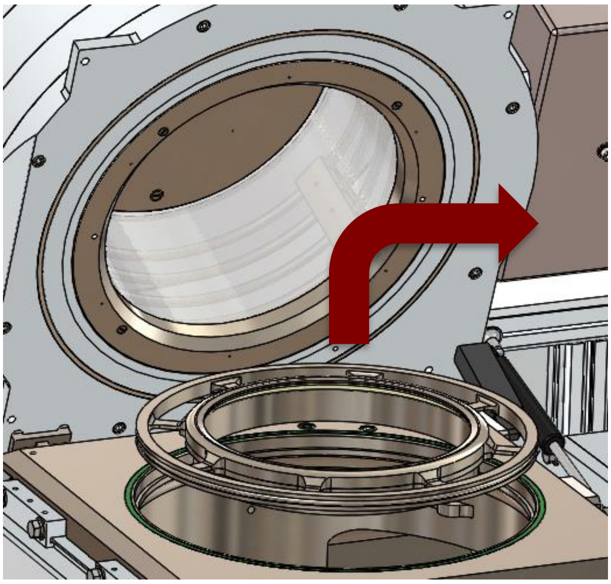


Figure 8 View of ICP reactor open without clamping tool

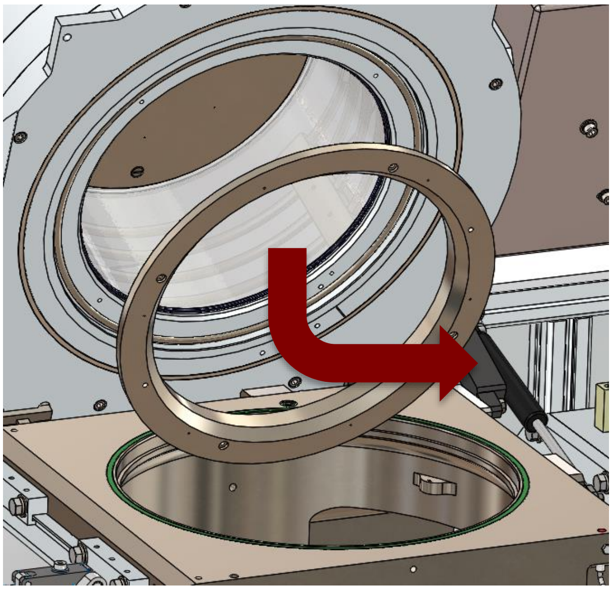


Figure 9 View of ICP reactor open without bottom protection

7. Remove the gas injector with the central part in peek (fixed with 4 screws).

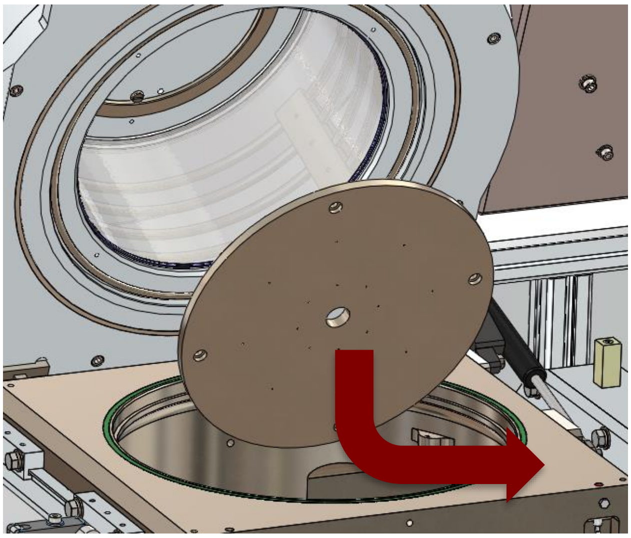


Figure 10 View of ICP reactor without the aluminum shower

8. Place the cover protection inside the laser porthole aperture in the reactor cover (check that the part does not fall down).

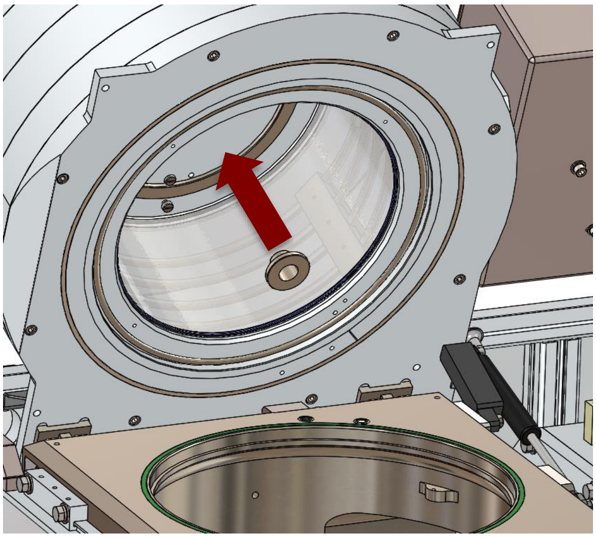


Figure 11 View of the reactor ICP open and the protection of the laser windows

9. Place the gas injector with quartz central cap on the quartz tube then enter the assembly smoothly inside the reactor. Check that the mark on the gas injector is well oriented.

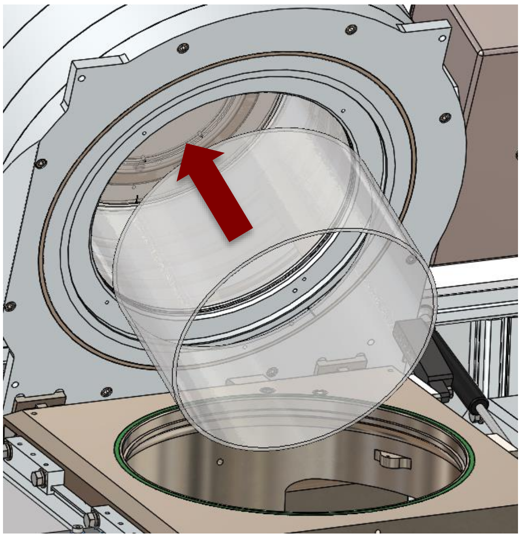


Figure 12 View of the reactor ICP open with quartz installation

Figure 13 Detailed view of the reactor ICP with the shower gas and alignment mark

10. While maintaining the quartz liner inside the reactor, place the bottom liner. The quartz liner is maintained by this part.

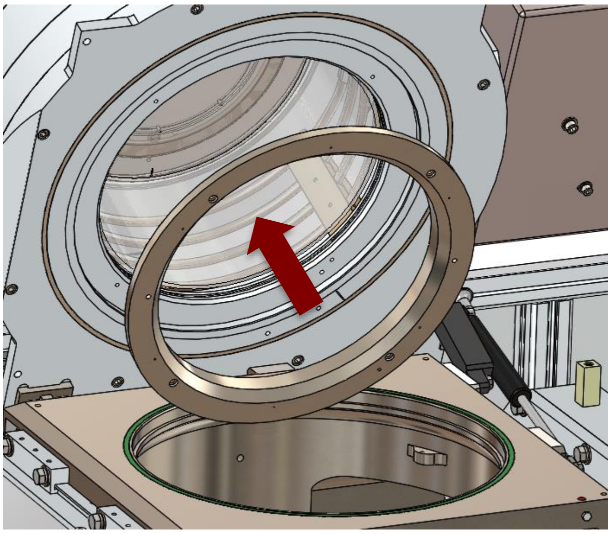


Figure 14 View of ICP reactor open with the liner protection

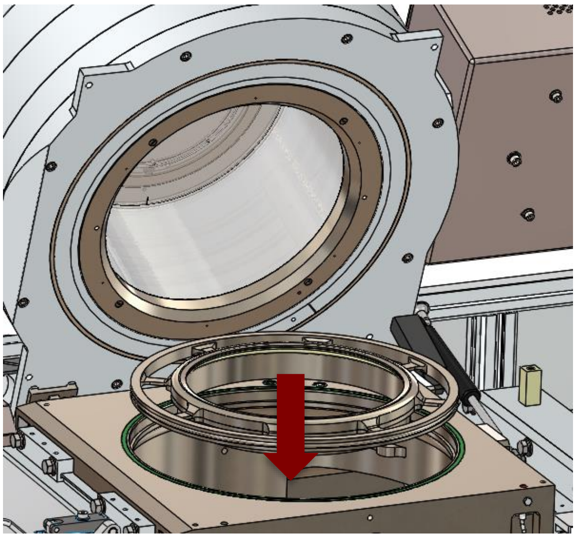


Figure 15 View of ICP reactor open with the clamping tool

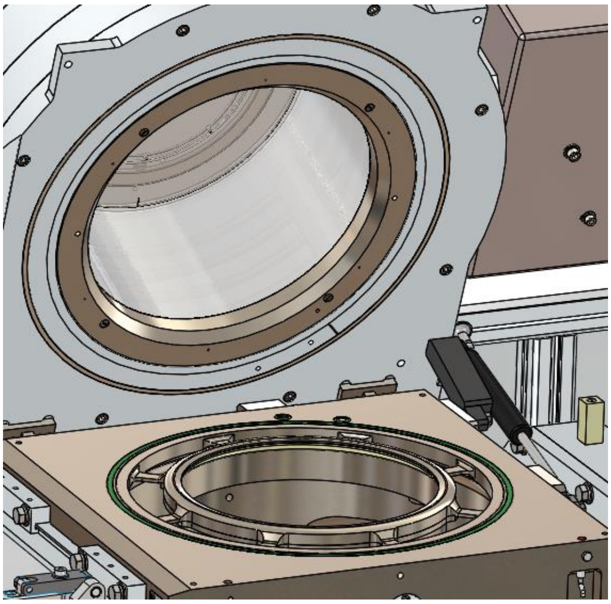


Figure 16 View of the ICP reactor ICP with all the element

1. Place the clamping tool.
2. Close the reactor and go back under vacuum with by selecting the chamber in the reactor scheme and by using the button 'Pump down' in the Windows Service/Vacuum system and open the chamber.
3. Screw the 4 screws of the reactor.
4. Place the two top panels of the reactor.
5. Reconnect RF cable from ICP matchbox.

In order to dismount the quartz liner, follow the same procedure in the opposite direction. To simplify removal of the bottom liner it is advisable to use the handle that has to be screw in the bottom part of the liner (supplied with the liner).

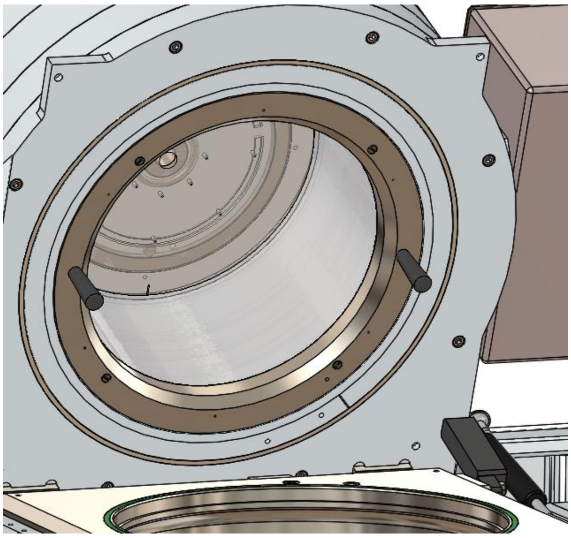


Figure 17 How to dismount the quartz liner

⚠ **WARNING**

Maintain the quartz liner by free hand otherwise it can fall down

⚠ **WARNING**

The quartz liner is hot after running ICP processes

7 COOLING PERFORMANCE OF THE CHILLER JULABO

Typically, it takes less than **10 min to reach 50°C from a coolant temperature of 20°C (and opposite).** The efficiency of the thermal isolation of cooling pipes and the cooling power of our chiller enables to start quickly a production run even if the coolant was at room temperature.

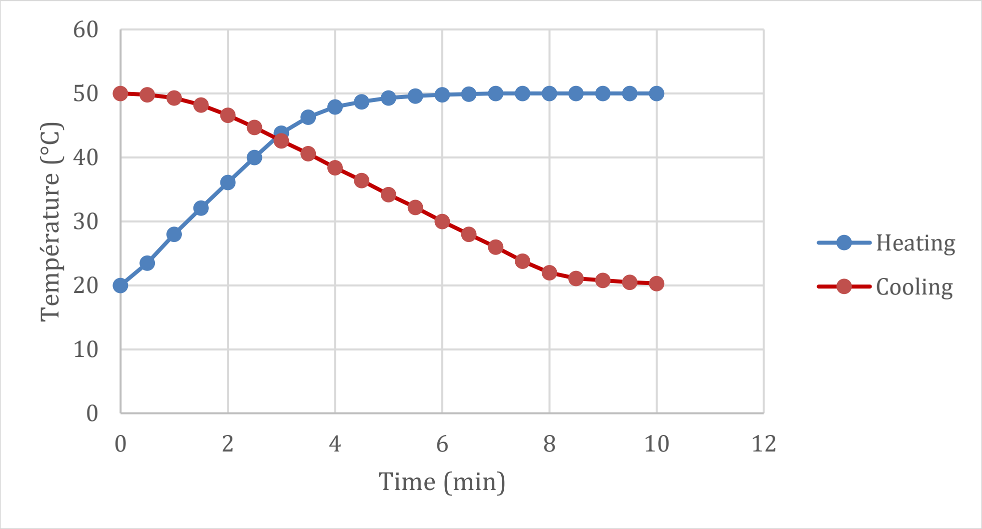


Figure 18 Chiller temperature of the cathode as function time (Chiller 21)

Typically, it takes less than **60 min to reach 80°C from temperature of 20°C (and opposite)**.

8 CONDITIONS TO BE FULFILLED TO RUN A PROCESS

8.1 Temperature, N2 and Exhaust settings For Dry Roughing Pump

Settings must be done according to the User's Manual provided by the pump manufacturer.

Settings for PFEIFFER A124H Dry Pump	
Dry Pump Temperature	100°C
N2 Purge Flow	> 50 slm

Settings for PFEIFFER A1600MT TMP	
TMP Temperature	75°C
N2 Purge Flow	50 sccm

8.2 TMP Pumping Capacity

TMP is operating at > 80% of its full capacity. The pumping performance is given in the Quality Control Sheet. As soon as the working pressure is **20% above the value** measured for a given flow rate of gas, the **TMP maintenance must be performed**.

8.3 Reactor and Load-lock Leak Rates

Operation actions must be stopped if either the **reactor leak rate is > 10 mT/min** or the **load-lock leak rate is > 20 mT/min**. In such a case, the reactor maintenance must be performed to get the system ready for operation.

9 PROCESSES WITH WAFER PREHEATING BY PLASMA

Wafers can be plasma-preheated to sustain processes requiring wafer temperatures that exceed maximum cathode chiller temperature. Examples of such processes are: ICPRIE of In-based III-V compounds, ICPCVD of dielectrics and aSiH, etc.

In order to increase wafer temperature, a heating step needs to be applied prior to the etching (deposition) step. A wafer is preferably placed on the NQ200 quartz plate shuttle. The temperature of the cathode is set at 20°C to allow shuttle cooling after the process is completed. The following recipe can be used as an example.

The following curves show the increasing of temperature as function of time.

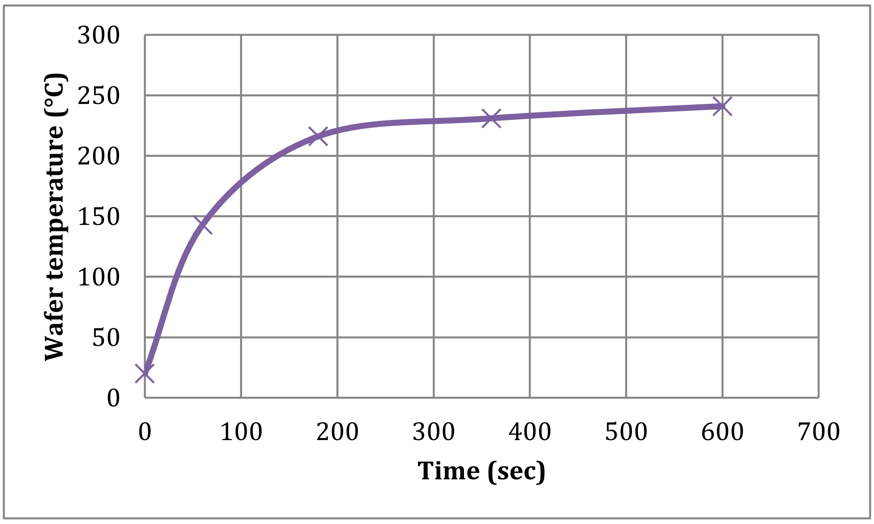


Figure 19 Wafer temperature as function of time, heat by plasma

Process conditions was with N_2 at 10mT, P_{ICP}=800 W

10 PLASMA ETCHING RECIPES

In order to have a reproducible process, a conditioning process before etching is mandatory. A conditioning process is a plasma with the same recipe used for the etching process and the same shuttle. We advise to run a conditioning plasma for 5-10 min for an etching of few minutes of few hours in order to condition the reactor walls.

This plasma will heat the wall of the reactor. Moreover, the wall will see the same chemistry after during the etching otherwise. So, from the first few minutes the plasma will see hot wall, and the same chemistry meaning that the plasma parameters and process will be stable.

Moreover, this conditioning process can play an important role on the uniformity.

When you run one process after one another of the same recipe, you only need to do a conditioning plasma before the first etching.

10.1 ICPRIE of SiN: “A_SiN_WF200” Recipe

This recipe is used for SiN etching. The process is based on CHF_3 chemistry and **cathode temperature 20°C**.

Process description:

- Make sure that a shuttle WF200 with a wafer is loaded in the machine.
- Extended Stabilization step of the recipe is needed for stabilization of the gas flows and shuttle temperature. Increased pressure during this step is needed to improve discharge ignition on the RF_ON step.
- The first steps are needed to establish the plasma
- Etching of SiN takes place during step Etching.
- Prolonged Purge step is required for shuttle cooling after long etching process.

The following table details the recipe:

Electrode (°C)	20

	1	2	3	4
	< Initial >	< Stabilization >	RF_ON	ICP_ON
Duration	0:10.0	Stabilized	0:03.0	0:02.0
Pressure (mTorr)	1	10	10	10
Throttle Position (%)				
Helium Pressure (mTo		5000		
Helium Flow (sccm)		5		
CHF3 (sccm)		30	30	30
O2 (sccm)		3	3	3
Bias (W)		0	150	150
AMN Mode		Manual	Manual	Manual
AMN Load (%)		33	0ms ¬ 3000ms ↕ 43.0	43
AMN Tune (%)		25	0ms ¬ 3000ms ↕ 15.0	15
ICP (W)		0	0	870
AMN Mode		Manual	Manual	Manual
AMN Load (%)		25	25	0ms ¬ 2000ms ↕ 35.0
AMN Tune (%)		72	72	72

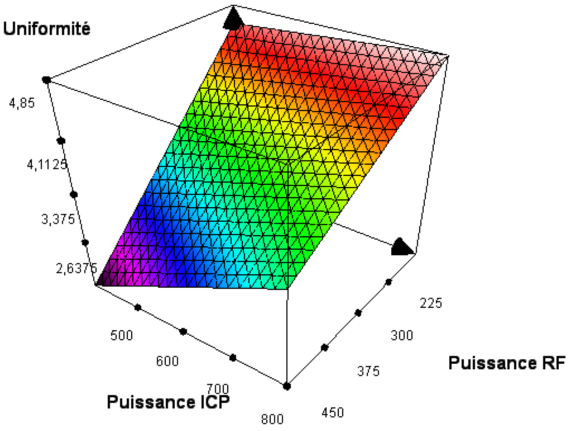
	5	6	7
	Go to Etch	Etch SiNx	< End >
Duration	0:05.0	1:00.0	0:10.0
Pressure (mTorr)	2.8	2.8	1
Throttle Position (%)			
Helium Pressure (mTo			
Helium Flow (sccm)			
CHF3 (sccm)	30	30	
O2 (sccm)	3	3	
Bias (W)	150	150	
AMN Mode	Manual	Man→Auto	
AMN Load (%)	14	15	
AMN Tune (%)	2.6	1.8	
ICP (W)	870	870	
AMN Mode	Man→Auto	Man→Auto	
AMN Load (%)	36.4	35.1	
AMN Tune (%)	80.8	82.2	

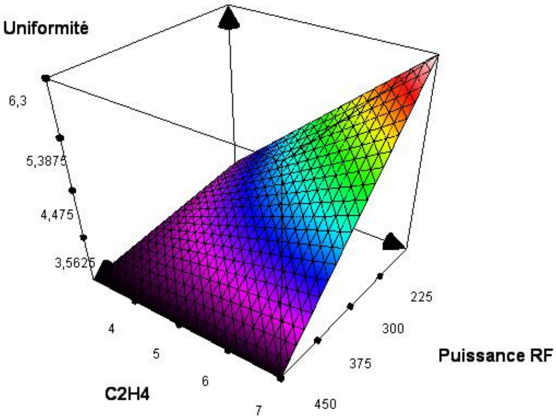
Process performances:

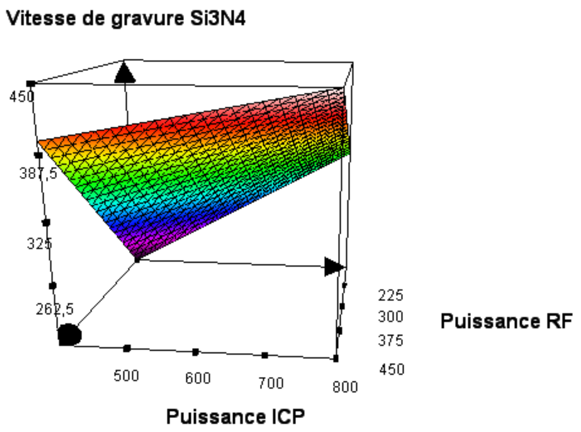
- Etch rate: 203 nm/min
- Uniformity WIW at 10 mm: 3.9%
- Uniformity WTW : 1.6%

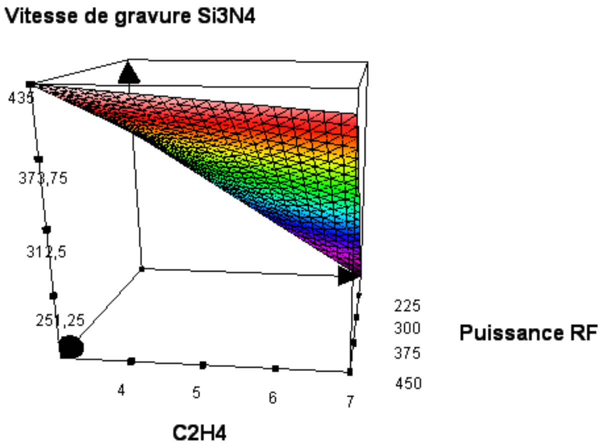
Process Notes:

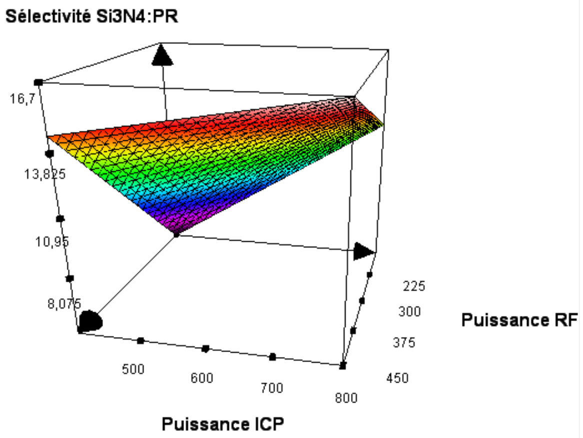
- Following graphics are just for information

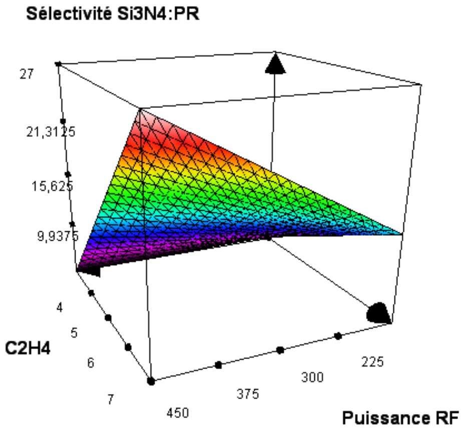





Vitesse de gravure Si3N4
450
387,5
325
262,5
500
600
700
800
Puissance ICP
225
300
375
450
Puissance RF


Vitesse de gravure Si3N4
435
373,75
312,5
251,25
4
5
6
7
C2H4
225
300
375
450
Puissance RF


Sélectivité Si3N4:PR
16,7
13,825
10,95
8,075
500
600
700
800
Puissance ICP
225
300
375
450
Puissance RF


Sélectivité Si3N4:PR
27
21,3125
15,625
9,9375
4
5
6
7
C2H4
450
375
300
225
Puissance RF

10.2 ICPRIE of SiO2: "A_SiO2_WF200" Recipe

This recipe is used for SiO_2 etching. The process is based on CHF_3 chemistry and **cathode temperature 20°C**.

Process description:

- Make sure that a shuttle WF200 with a wafer is loaded in the machine.
- Extended Stabilization step of the recipe is needed for stabilization of the gas flows and shuttle temperature. Increased pressure during this step is needed to improve discharge ignition on the RF_ON step.
- The first steps are needed to establish the plasma
- Etching of SiO_2 takes place during step Etching.
- Prolonged Purge step is required for shuttle cooling after long etching process.

The following table details the recipe:

	1	2	3	4
	< Initial >	< Stabilization >	RF_ON	ICP_ON
Duration	0:10.0	Stabilized	0:03.0	0:02.0
Pressure (mTorr)	1	10	10	10
Throttle Position (%)				
Helium Pressure (mTo		5000		
Helium Flow (sccm)		5		
CHF3 (sccm)		30	30	30
O2 (sccm)		3	3	3
Bias (W)		0	200	200
AMN Mode		Manual	Manual	Manual
AMN Load (%)		33	0ms ¬ 3000ms ↕ 43.0	43
AMN Tune (%)		25	0ms ¬ 3000ms ↕ 15.0	15
ICP (W)		0	0	900
AMN Mode		Manual	Manual	Manual
AMN Load (%)		25	25	0ms ¬ 2000ms ↕ 35.0
AMN Tune (%)		72	72	72

- PROCESSES -

INDUCTIVELY COUPLED PLASMA SYSTEM - Corial 210IL S/N: 156

	5	6	7
	Go to Etch	Etch SiO2	< End >
Duration	0:05.0	1:00.0	0:10.0
Pressure (mTorr)	2.6	2.6	1
Throttle Position (%)			
Helium Pressure (mTo			
Helium Flow (sccm)			
CHF3 (sccm)	30	30	
O2 (sccm)	3	3	
Bias (W)	200	200	
AMN Mode	Manual	Man→Auto	
AMN Load (%)	14	15	
AMN Tune (%)	2.4	1.9	
ICP (W)	900	900	
AMN Mode	Man→Auto	Man→Auto	
AMN Load (%)	36.4	34.8	
AMN Tune (%)	82	83	

Process performances:

Etch rate:	160 nm/min
Uniformity WIW at mm:	4.3%
Uniformity WTW:	1%

11 PLASMA CLEANING RECIPES

11.1 Plasma Cleaning: "B_CLEAN_WF200" Recipe

This recipe is used for reactor and shuttle cleaning from deposited polymer layers and to heat up the reactor before ICPRIE if the reactor was not used for prolonged time (>45 min).

The process is based on O_2/CHF_3 chemistry. The reactor is clean when the throttle valve position is stable.

The process run at the current temperature, so no need to change the temperature between your process and the cleaning recipe.

We strongly recommend running a cleaning process after your run of etching, to keep the reactor clean for the next use. It is not needed to run a cleaning process between all your run if you use the same chemistry for a low etching time.

Few examples of when run a plasma cleaning:

- After a long total time, process etching. It can be 1 etching with long time or several etchings. You will need to run a conditioning plasma after the cleaning process
- After ventilation of the reactor
- When the status of the reactor is unknow
- When the reactor will not be used for long time. In order to keep the reactor clean during the standby time.

Process description:

- Make sure that the shuttle is loaded in the reactor.
- The first steps are needed to establish the plasma

Electrode (°C)	Current

	1	2	3	4	5
	< Initial >	< Stabilization >	RF_ON	ICP_ON	GoTo Clean
Duration	0:10.0	Stabilized	0:03.0	0:02.0	0:05.0
Pressure (mTorr)	1	10	10	10	10
Throttle Position (%)					
Helium Pressure (mTo		5000			
Helium Flow (sccm)		5			
CHF3 (sccm)		15	15	15	15
O2 (sccm)		100	100	100	100
Bias (W)		0	200	200	0
AMN Mode		Manual	Manual	Manual	Manual
AMN Load (%)		45	0ms ¬ 3000ms ↕ 43.0	43	43
AMN Tune (%)		12	0ms ¬ 3000ms ↕ 15.0	15	12
ICP (W)		0	0	800	800
AMN Mode		Manual	Manual	Manual	Manual
AMN Load (%)		31	39	0ms ¬ 2000ms ↕ 39.0	38
AMN Tune (%)		64	64	64	65

	6	7	8	9
	Clean phase1	Clean phase 2	Purge	< End >
Duration	5:00.0	5:00.0	0:10.0	0:10.0
Pressure (mTorr)	10	10		1
Throttle Position (%)			100	
Helium Pressure (mTo				
Helium Flow (sccm)				
CHF3 (sccm)	15	15	0	
O2 (sccm)	100	100	100	
Bias (W)	0	0	0	
AMN Mode	Manual	Manual	Manual	
AMN Load (%)	34	34	34	
AMN Tune (%)	20	20	20	
ICP (W)	800	800	0	
AMN Mode	Man→Auto	Man→Auto	Manual	
AMN Load (%)	38.5	38.5	40.1	
AMN Tune (%)	65.2	65.5	65.6	

Typical view of the inside of ICP reactor before and after plasma cleaning:

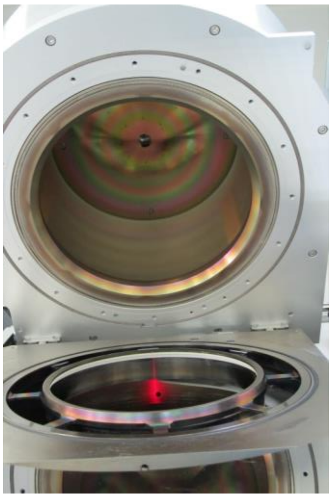


Figure 20 Photo of the inside of the reactor after etching and before cleaning

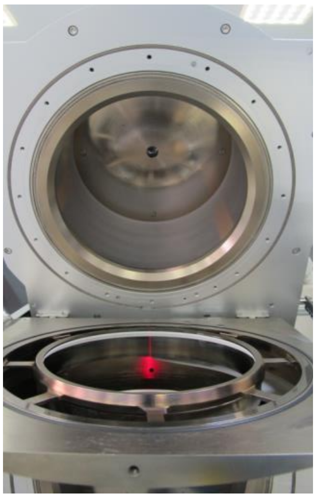
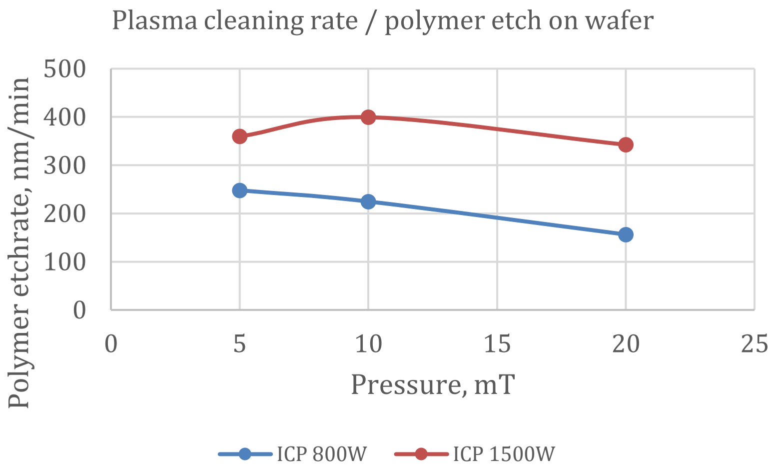


Figure 21 Photo of the inside of the reactor after etching and after cleaning

Process trends:

Etching rate of polymer deposited on wafer is shown below:


Plasma cleaning rate / polymer etch on wafer
Polymer etchrate, nm/min
500
400
300
200
100
0
0
5
10
15
20
25
Pressure, mT
ICP 800W
ICP 1500W