

LibreSilicon process HKUST (NFF)

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June 18, 2018

Abstract

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This document is part of the specification of the free silicon manufacturing standard for manufacturing the LibreSilicon standard logic cells¹ and related free technology nodes from the LibreSilicon project.

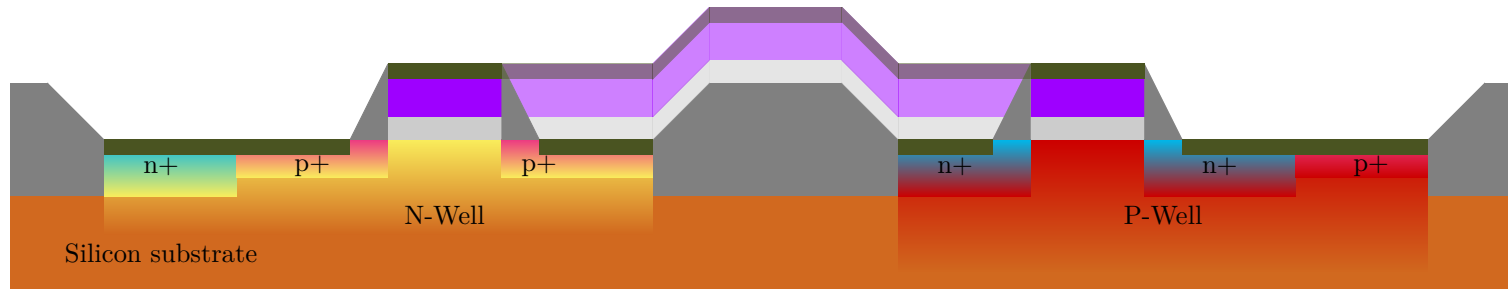
For this initial revision 0.1 a gate-first approach has been chosen which led to the choice of polysilicon as the gate electrode material because of the simplicity of the gate alignment. For better isolation properties of the transistors and gates in overall a box-isolation approach has been chosen. All of these choices have been made with the future scale down from the recent $1\mu m$ to smaller structure sizes. **This process is for manufacturing $1\mu m$ only!** But further releases which will have been tested with smaller structure sizes can be expected. Please see the document with the generic steps² in order to get a detailed description of the different steps.

¹<https://github.com/chipforge/StdCellLib>

²https://github.com/leviathanch/libresiliconprocess/raw/master/process_steps/process_steps.pdf

Process Flow of Lanceville Technologies LibreSilicon 180nm

- Project: LibreSilicon 1 μ m
- Name: Lanceville Technologies Group
- Substrate: P-Substrate silicon wafer <100>
- Date: June 18, 2018



1 Shallow trench isolation

Silicon substrate

Mask: active

Wafer Cleanliness	Step Number	Equipment	Location	Cleanliness	Process	Requirements
Clean	1.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Initial Cleaning	H2SO4+H2O2, 10mins @ 120°C
Clean	1.2	A2:HF:H2O (1:50) (WET-A2)	P2-01000	Clean	HF dip	1 min
Clean	1.3	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	1.4	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	100nm, 5 minutes 30 seconds @ 1050°C , wet ambient
Clean	1.5	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean	1.6	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean	1.7	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean	1.8	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Oxide Etch	1 minute
Clean	1.9	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean	1.10	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4 + H2O2, 120°C , 10mins
Clean	1.11	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
Clean	1.12	DRIE Etcher #1 (DRY-Si-1)	P2-01000	Clean	Etching the trenches	1 minute (2μm)
Clean	1.13	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Hard mask removal	1 minute
Clean	1.14	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

2 P-well



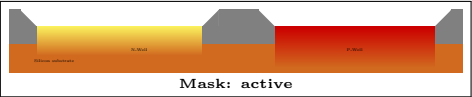
Wafer Cleanli- ness	Step Num- ber	Equipment	Location	Cleanliness	Process	Requirements
Clean	2.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	2.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	2.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	500nm, 56 minutes @ 1050°C , wet ambient
Clean	2.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean	2.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean	2.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean	2.7	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Oxide Etch	5 minutes
Clean	2.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean	2.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Clean	2.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
Clean	2.11	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Boron implant	$2.5 \times 10^{12} cm^{-2}$ @100keV
Clean	2.12	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	2.13	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	2.14	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N ₂
Clean	2.15	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Hard mask removal	5 minutes
Clean	2.16	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

3 N-well



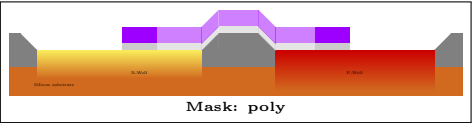
Wafer Cleanli- ness	Step Num- ber	Equipment	Location	Cleanliness	Process	Requirements
Clean	3.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	3.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	3.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	200nm, 14 minutes @ 1050°C , wet ambient
Clean	3.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean	3.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean	3.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean	3.7	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	2 minutes
Clean	3.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean	3.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Clean	3.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
Clean	3.11	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Phorphorus implant	$2.5 \times 10^{12} cm^{-2}$ @100keV
Clean	3.12	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	3.13	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	3.14	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N ₂
Clean	3.15	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	2 minutes
Clean	3.16	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

4 Field oxide



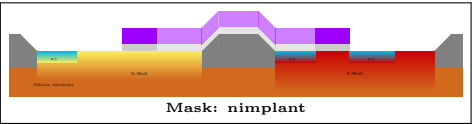
Wafer Cleanli- ness	Step Num- ber	Equipment	Location	Cleanliness	Process	Requirements
Clean	4.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	4.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	4.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Thick oxide growth	1μm , 3 hours @ 1050°C in wet environment
Clean	4.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean	4.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean	4.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean	4.7	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Hard mask removal	10 minutes
Clean	4.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean	4.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Clean	4.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	

5 Gate



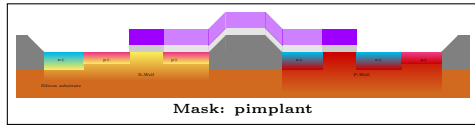
Wafer ness	Cleanli-	Step ber	Num- ber	Equipment	Location	Cleanliness	Process	Requirements
Clean		5.1		A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean		5.2		Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean		5.3		Diffusion Furnace-D2, dry oxidation (DIF-D1)	P2-01000	Clean	Gate oxide growth	40nm, 33 minutes 14 seconds @ 1050°C in dry environment
Clean		5.4		A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean		5.5		Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean		5.6		LPCVD-A3: Amor-Si/Poly (CVD-A3)	P2-01000	Clean	Gate electrode growth	600nm of poly silicon
Clean		5.7		SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean		5.8		ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean		5.9		SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean		5.10		Poly etcher (DRY-Poly)	P2-01000	Clean Semi clean	Poly silicon etch	6 minute 10 seconds (600nm poly + 40nm oxide)
Clean		5.11		E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Clean		5.12		Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	

6 N+ implant



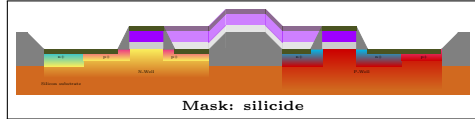
Wafer Cleanli- ness	Step Num- ber	Equipment	Location	Cleanliness	Process	Requirements
Clean	6.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	6.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	6.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	100nm, 5 minutes 30 seconds @ 1050°C , wet ambient
Clean	6.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean	6.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean	6.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean	6.7	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	1 minutes
Clean	6.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean	6.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Clean	6.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
Clean	6.11	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Phosphorus implant	$2.5 \times 10^{12} cm^{-2}$ @100keV
Clean	6.12	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	6.13	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	6.14	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N ₂
Clean	6.15	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	1 minutes
Clean	6.16	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

7 P+ implant



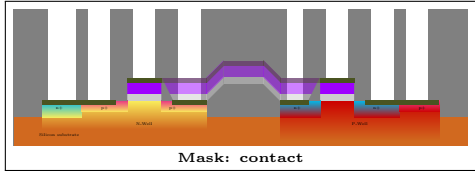
Wafer ness	Cleanli-	Step ber	Equipment	Location	Cleanliness	Process	Requirements
Clean		7.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean		7.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean		7.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	100nm, 5 minutes 30 seconds @ 1050°C , wet ambient
Clean		7.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean		7.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean		7.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean		7.7	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	1 minutes
Clean		7.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean		7.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Clean		7.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
Clean		7.11	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Boron implant	$2.5 \times 10^{12} cm^{-2}$ @100keV
Clean		7.12	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean		7.13	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean		7.14	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N ₂
Clean		7.15	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	1 minutes
Clean		7.16	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

8 Silicification



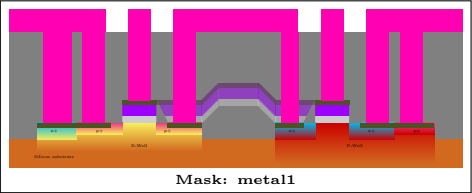
Wafer- ness	Cleanli- ness	Step Num- ber	Equipment	Location	Cleanliness	Process	Requirements
	Clean	8.1	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
	Clean	8.2	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
	Clean	8.3	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
	Clean	8.4	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	2 minutes
	Clean	8.5	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
	Clean	8.6	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
	Clean	8.7	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
	Clean	8.8	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Phorphorus implant	$2.5 \times 10^{12} cm^{-2}$ @100keV
	Clean	8.9	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
	Clean	8.10	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
	Clean	8.11	Diffusion Furnace-A1, an- neal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N ₂
	Clean	8.12	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	2 minutes
	Clean	8.13	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

9 Contact



Wafer	Cleanli- ness	Step Num- ber	Equipment	Location	Cleanliness	Process	Requirements
	<div>Clean</div>	9.1	SVG Coater Track (PHT-T1)	P2-00100	<div>Clean</div> <div>Semi clean</div>	HMDS, PR coating, soft bake	
	<div>Clean</div>	9.2	ASML Stepper (PHT-S1)	P2-00100	<div>Clean</div> <div>Semi clean</div>	Exposure of the layer	
	<div>Clean</div>	9.3	SVG Developer Track (PHT-T2)	P2-00100	<div>Clean</div> <div>Semi clean</div>	Develop, Hard bake	
	<div>Clean</div>	9.4	C3:BOE (WET-C3)	P2-01000	<div>Clean</div>	Oxide Etch	2 minutes
	<div>Clean</div>	9.5	Spin Dryer-C (SRD-C)	P2-01000	<div>Clean</div>	Dry the wafer automatically	
	<div>Clean</div>	9.6	E4:Resist strip (WET-E4)	P2-01000	<div>Clean</div> <div>Semi clean</div>	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
	<div>Clean</div>	9.7	Spin Dryer-E (SRD-E)	P2-01000	<div>Clean</div> <div>Semi clean</div>	Dry the wafer automatically	
	<div>Clean</div>	9.8	CF-3000 Implanter (IMP-3000)	P2-01000	<div>Clean</div> <div>Semi clean</div>	Phorphorus implant	$2.5 \times 10^{12} \text{ cm}^{-2}$ @100keV
	<div>Clean</div>	9.9	A3:Sulfuric cleaning (WET-A3)	P2-01000	<div>Clean</div>	Default cleaning	
	<div>Clean</div>	9.10	Spin Dryer-A (SRD-A)	P2-01000	<div>Clean</div>	Dry the wafer automatically	
	<div>Clean</div>	9.11	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	<div>Clean</div>	Annealing	Annealing 30 minutes @ 1050°C with N ₂
	<div>Clean</div>	9.12	C3:BOE (WET-C3)	P2-01000	<div>Clean</div>	Hard mask removal	2 minutes
	<div>Clean</div>	9.13	Spin Dryer-C (SRD-C)	P2-01000	<div>Clean</div>	Dry the wafer automatically	

10 Metal 1



Wafer-ness	Cleanli-ness	Step Num-ber	Equipment	Location	Cleanliness	Process	Requirements
Clean		10.1	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean		10.2	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean		10.3	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean		10.4	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	2 minutes
Clean		10.5	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean		10.6	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Clean		10.7	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
Clean		10.8	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Phorphorus implant	$2.5 \times 10^{12} cm^{-2}@100keV$
Clean		10.9	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean		10.10	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean		10.11	Diffusion Furnace-A1, an-neal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N ₂
Clean		10.12	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	2 minutes
Clean		10.13	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	