LibreSilicon process HKUST (NFF)

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June 16, 2018

Abstract

This document is part of the specification of the free silicon manufacturing standard for manufacturing the LibreSilicon standard logic cells[1] and related free technology nodes from the LibreSilicon project.

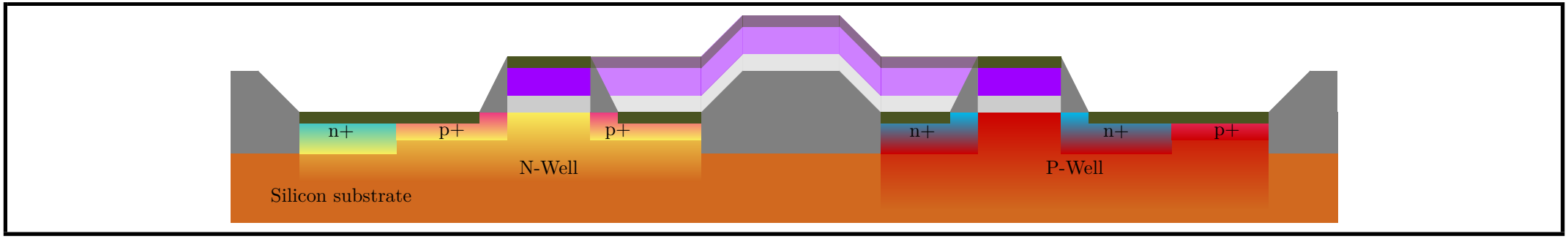
For this initial revision 0.1 a gate-first approach has been chosen which led to the choice of polysilicon as the gate electrode material because of the simplicity of the gate alignment. For better isolation properties of the transistors and gates in overall a box-isolation approach has been chosen. 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 steps[2] in order to get a detailed description of the different steps.

[1] `https://github.com/chipforge/StdCellLib`

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

Process Flow of Lanceville Technologies LibreSilicon 180nm

- Project: LibreSilicon $1\mu m$
- Name: Lanceville Technologies Group
- Substrate: P-Substrate silicon wafer <100>
- Date: June 16, 2018



1 Shallow trench isolation

Mask: active

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

2 P-well

Mask: pwell

Wafer Cleanliness
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Step Number	Equipment	Location	Cleanliness	Process	Requirements
2.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
2.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
2.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	500nm, 56 minutes @ 1050°C , wet ambient
2.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
2.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
2.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
2.7	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Oxide Etch	5 minutes
2.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
2.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
2.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
2.11	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Boron implant	$2.5 \times 10^{12} cm^{-2}$@100keV
2.12	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
2.13	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
2.14	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N_2
2.15	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Hard mask removal	5 minutes
2.16	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

3 N-well

Mask: nwell

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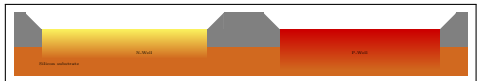
Step Number	Equipment	Location	Cleanliness	Process	Requirements
3.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
3.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
3.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	200nm, 14 minutes @ 1050°C , wet ambient
3.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
3.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
3.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
3.7	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	2 minutes
3.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
3.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
3.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
3.11	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Phorphorus implant	$2.5 \times 10^{12} cm^{-2}$@100keV
3.12	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
3.13	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
3.14	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N_2
3.15	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	2 minutes
3.16	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

4 Field oxide



Mask: active

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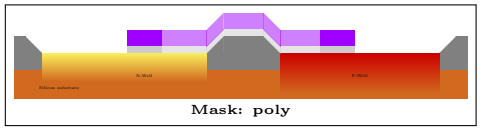
Step Number	Equipment	Location	Cleanliness	Process	Requirements
4.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
4.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
4.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Thick oxide growth	$1\mu m$, 3 hours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

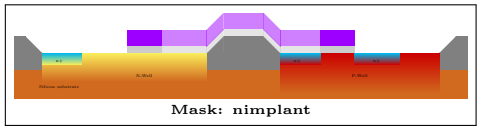
5 Gate



Mask: poly

Wafer Cleanliness	Step Number	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


Mask: nimplant

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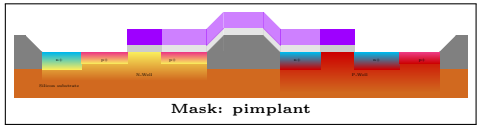
Step Number	Equipment	Location	Cleanliness	Process	Requirements
6.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
6.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
6.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	100nm, 5 minutes 30 seconds @ 1050°C , wet ambient
6.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
6.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
6.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
6.7	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	1 minutes
6.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
6.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
6.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
6.11	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Phorphorus implant	$2.5 \times 10^{12} cm^{-2}$@100keV
6.12	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
6.13	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
6.14	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N_2
6.15	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	1 minutes
6.16	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

7 P+ implant



Mask: pimplant

Wafer Cleanliness
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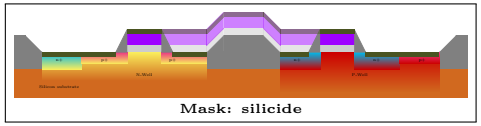
Step Number	Equipment	Location	Cleanliness	Process	Requirements
7.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
7.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
7.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard mask dioxide growth	100nm, 5 minutes 30 seconds @ 1050°C , wet ambient
7.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
7.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
7.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
7.7	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	1 minutes
7.8	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
7.9	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
7.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
7.11	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Boron implant	$2.5 \times 10^{12} cm^{-2}$@100keV
7.12	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
7.13	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
7.14	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N_2
7.15	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	1 minutes
7.16	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

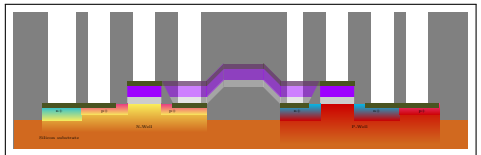
8 Silicification



Mask: silicide

Wafer Cleanliness	Step Number	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, anneal/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



Mask: contact

Wafer Cleanliness	Step Number	Equipment	Location	Cleanliness	Process	Requirements
Clean	9.1	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean	9.2	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean	9.3	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean	9.4	C3:BOE (WET-C3)	P2-01000	Clean	Oxide Etch	2 minutes
Clean	9.5	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean	9.6	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Clean	9.7	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
Clean	9.8	CF-3000 Implanter (IMP-3000)	P2-01000	Clean Semi clean	Phorphorus implant	$2.5 \times 10^{12} cm^{-2}$@100keV
Clean	9.9	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	9.10	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	9.11	Diffusion Furnace-A1, anneal/oxidation (DIF-A1)	P2-01000	Clean	Annealing	Annealing 30 minutes @ 1050°C with N_2
Clean	9.12	C3:BOE (WET-C3)	P2-01000	Clean	Hard mask removal	2 minutes
Clean	9.13	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	