

LibreSilicon process HKUST (NFF)

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June 26, 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.

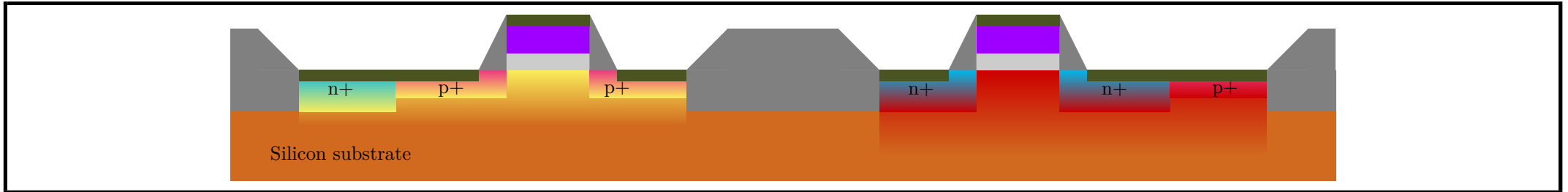
For this initial revision 0.1 a gate-first approach has been chosen which led to the choice of polysilicon as the gate electrode material because of the simplicity of the gate alignment. For better isolation properties of the transistors and gates in overall a box-isolation approach has been chosen. 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 μm
- Name: Lanceville Technologies Group
- Substrate: P-Substrate silicon wafer <100>
- Date: June 26, 2018



1 Shallow trench isolation



Wafer ness	Cleanli-	Step ber	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	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean		1.3	A2:HF:H2O (1:50) (WET-A2)	P2-01000	Clean	HF dip	1 min
Clean		1.4	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean		1.5	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		1.6	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Clean		1.7	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Clean		1.8	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Clean		1.9	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Oxide Etch	1 minute
Clean		1.10	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	
Clean		1.11	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4 + H2O2, 120°C , 10mins
Clean		1.12	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
Clean		1.13	DRIE Etcher #1 (DRY-Si-1)	P2-01000	Clean	Etching the trenches	1 minute (2μm)
Clean		1.14	C3:BOE (WET-C3)	P2-01000	Clean	BOE: Hard mask removal	1 minute
Clean		1.15	Spin Dryer-C (SRD-C)	P2-01000	Clean	Dry the wafer automatically	

2 P-well



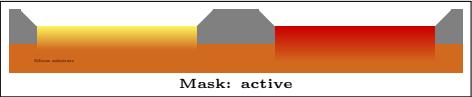
Wafer Cleanli- ness	Step Num- ber	Equipment	Location	Cleanliness	Process	Requirements
Clean	2.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	2.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	2.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	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



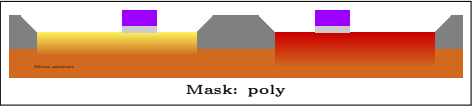
Wafer	Cleanli-	Step	Num-	Equipment	Location	Cleanliness	Process	Requirements
	ness	ber						
	Clean	3.1		A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
	Clean	3.2		Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
	Clean	3.3		Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	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



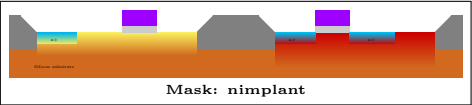
Wafer Cleanli-ness	Step Num-ber	Equipment	Location	Cleanliness	Process	Requirements
Clean	4.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	4.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	4.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Thick oxide growth	1.23 μm , 4 hours 30 minutes @ 1050 $^{\circ}$ 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: Field oxide etching	12 minutes 30 seconds
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 $^{\circ}$ C , 10mins
Clean	4.10	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	

5 Gate



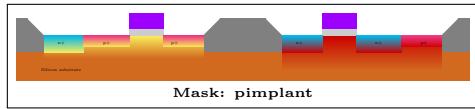
Wafer ness	Cleanli-	Step ber	Num- ber	Equipment	Location	Cleanliness	Process	Requirements
Clean		5.1		A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean		5.2		Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean		5.3		Diffusion Furnace-D2, dry oxidation (DIF-D1)	P2-01000	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



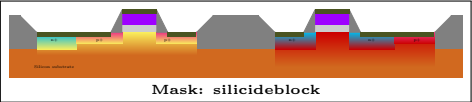
Wafer Cleanli-	Step Num-	Equipment	Location	Cleanliness	Process	Requirements
Clean	6.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
Clean	6.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
Clean	6.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	Clean	Hard 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	$2.5 \times 10^{12} cm^{-2}$ @ 35keV
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 10 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



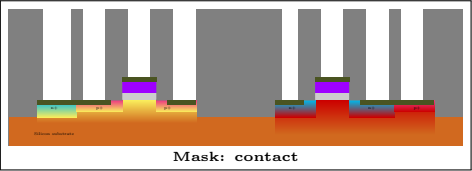
Wafer ness	Cleanli- ness	Step ber	Equipment	Location	Cleanliness	Process	Requirements
	Clean	7.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
	Clean	7.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
	Clean	7.3	Diffusion Furnace-D2, dry/wet oxidation (DIF-D2)	P2-01000	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	$2.5 \times 10^{12} cm^{-2}$ @ 13keV
	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



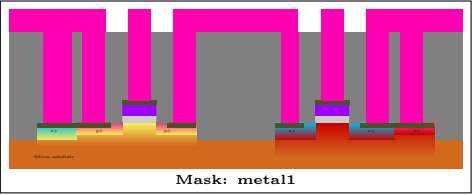
Wafer- ness	Cleanli- ness	Step Num- ber	Equipment	Location	Cleanliness	Process	Requirements
	Clean	8.1	A3:Sulfuric cleaning (WET-A3)	P2-01000	Clean	Default cleaning	
	Clean	8.2	Spin Dryer-A (SRD-A)	P2-01000	Clean	Dry the wafer automatically	
	Clean	8.3	LPCVD-B3 LTO (CVD-B3)	P2-01000	Clean	Spacer oxide	50 nm
	Clean	8.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
	Clean	8.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
	Clean	8.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
	Clean	8.7	AOE Etcher (DRY-AOE)	P2-01000	Clean	Anisotropic oxide etch	12 seconds
	Clean	8.8	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
	Clean	8.9	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
	Semi clean	8.10	Varian 3180 Sputter (SPT-3180)	P2-01000	Semi clean	Deposit Titanium	15 seconds (roughly 60nm)
	Semi clean	8.11	AG610 RTP (DIF-R2)	P2-01000	Semi clean	First reaction phase	240 seconds @ 700°C
	Semi clean	8.12	E2: General purpose (WET-E2)	P2-01000	Semi clean	Remove unreacted Titanium	APM solution (Ammonia and Hydrogen Peroxide mixture), 1 minute
	Semi clean	8.13	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	
	Semi clean	8.14	AG610 RTP (DIF-R2)	P2-01000	Semi clean	Second reaction phase	240 seconds @ 800°C

9 Contact



Wafer Cleanli-ness	Step Num-ber	Equipment	Location	Cleanliness	Process	Requirements
Semi clean	9.1	D1: Dump rinse (WET-D-DR)	P2-01000	Semi clean	Wafer cleaning	
Semi clean	9.2	Spin Dryer-D (SRD-D)	P2-01000	Semi clean	Dry the wafer automatically	
Semi clean	9.3	LPCVD-F4 LTO/PSG (CVD-F4)	P2-01000	Semi clean	Oxide deposition	4μm
Semi clean	9.4	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Semi clean	9.5	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Semi clean	9.6	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Semi clean	9.7	Trion RIE Etcher (DRY-Trion)	P2-01000	Semi clean	Oxide Etch	80 minutes (4μm)
Semi clean	9.8	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120° C , 10mins
Semi clean	9.9	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	

10 Metal 1



Wafer Cleanliness	Step Number	Equipment	Location	Cleanliness	Process	Requirements
Semi clean	10.1	Varian 3180 Sputter (SPT-3180)	P2-01000	Semi clean	Deposit Aluminum	15 seconds (roughly 60nm)
Semi clean	10.2	SVG Coater Track (PHT-T1)	P2-00100	Clean Semi clean	HMDS, PR coating, soft bake	
Semi clean	10.3	ASML Stepper (PHT-S1)	P2-00100	Clean Semi clean	Exposure of the layer	
Semi clean	10.4	SVG Developer Track (PHT-T2)	P2-00100	Clean Semi clean	Develop, Hard bake	
Semi clean	10.5	Oxford Aluminum Etcher (DRY-Metal-2)	P2-01000	Semi clean	Wire formation	4μm
Semi clean	10.6	E4:Resist strip (WET-E4)	P2-01000	Clean Semi clean	Sulfuric resist strip	H2SO4+H2O2, 120°C , 10mins
Semi clean	10.7	Spin Dryer-E (SRD-E)	P2-01000	Clean Semi clean	Dry the wafer automatically	