

# LibreSilicon process HKUST (NFF)

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October 6, 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 cells<sup>1</sup> 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<sup>2</sup> in order to get a detailed description of the different steps.

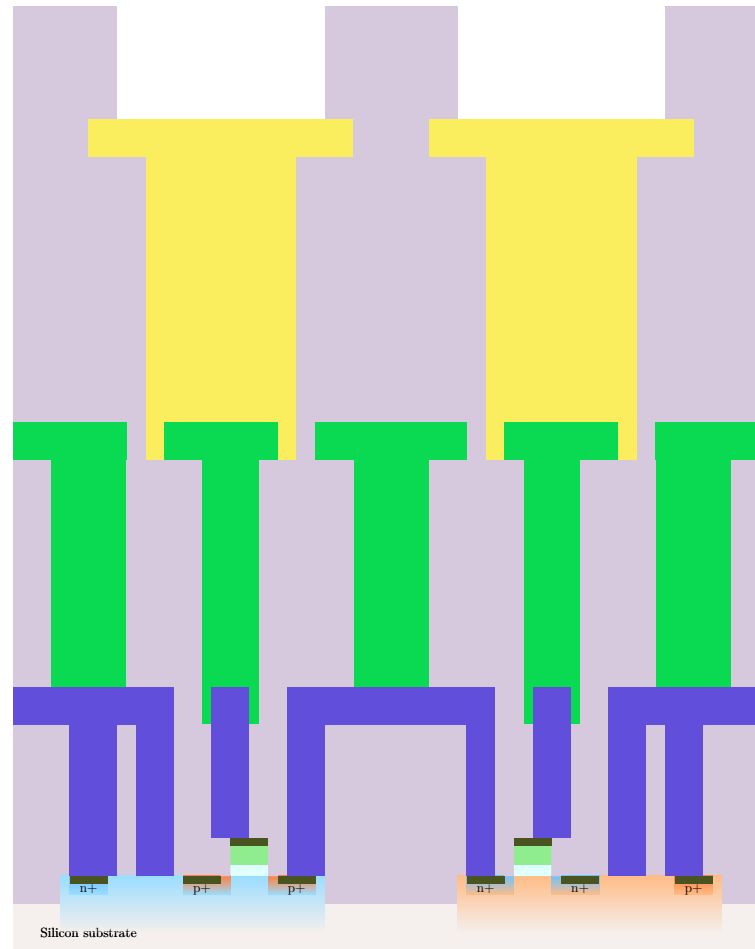
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<sup>1</sup><https://github.com/chipforge/StdCellLib>

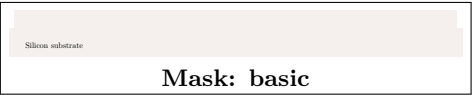
<sup>2</sup>[https://github.com/libresilicon/process/raw/master/process\\_steps/process\\_hightech/process\\_hightech\\_steps.pdf](https://github.com/libresilicon/process/raw/master/process_steps/process_hightech/process_hightech_steps.pdf)

## Process Flow of Lanceville Technologies LibreSilicon $1\mu m$

- Project: LibreSilicon  $1\mu m$
- Name: Lanceville Technologies Group
- Substrate: P-Substrate silicon wafer  $\langle 100 \rangle$
- Date: October 6, 2018

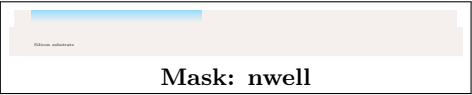


1 Initial alignment mask



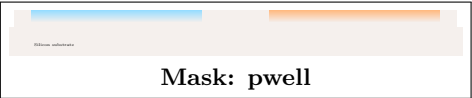
| Wafer<br>ness | Cleanli- | Step<br>ber | Equipment                      | Location | Cleanliness      | Process                                  | Requirements   |
|---------------|----------|-------------|--------------------------------|----------|------------------|--|--|
| Clean         |          | 1.1         | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean            | Default cleaning                         |  |
| Clean         |          | 1.2         | Spin Dryer-B (SRD-B)           | P2-01000 | Clean            | Dry the wafer automatically              |  |
| Clean         |          | 1.3         | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake              | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Clean         |          | 1.4         | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer                    |  |
| Clean         |          | 1.5         | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake                       | FHD-5, 1min; hard bake: 120°C , 1min                         |
| Clean         |          | 1.6         | Lam 490 etcher (DRY-490)       | P2-01000 | Clean            | Etching the alignment crosses from HKUST | 2 minutes (120nm)  |
| Clean         |          | 1.7         | PS210 Asher (DRY-PR-1)         | P2-01000 | Clean            | Resist strip                             |  |
| Clean         |          | 1.8         | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Resist strip                             |  |
| Clean         |          | 1.9         | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically              |  |

2 N-well



| Wafer<br>ness | Cleanli- | Step<br>ber | Equipment                      | Location | Cleanliness      | Process                     | Requirements  |
|---------------|----------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean         |          | 2.1         | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean            | Default cleaning            |   |
| Clean         |          | 2.2         | Spin Dryer-B (SRD-B)           | P2-01000 | Clean            | Dry the wafer automatically |   |
| Clean         |          | 2.3         | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | FH 6400L: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Clean         |          | 2.4         | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer       |   |
| Clean         |          | 2.5         | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                          |
| Clean         |          | 2.6         | CF-3000 Implanter (IMP-3000)   | P2-01000 | Clean Semi clean | Phorphorus implant          | $2.33 \times 10^{12} cm^{-2}$ @110keV                         |
| Clean         |          | 2.7         | PS210 Asher (DRY-PR-1)         | P2-01000 | Clean            | Resist strip                |   |
| Clean         |          | 2.8         | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Resist strip                |   |
| Clean         |          | 2.9         | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |   |

3 P-well



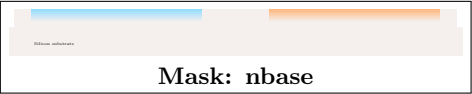
| Wafer<br>ness | Cleanli- | Step<br>ber | Num-<br>ber | Equipment                      | Location | Cleanliness      | Process                     | Requirements  |
|---------------|----------|-------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean         |          | 3.1         |             | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean            | Default cleaning            |   |
| Clean         |          | 3.2         |             | Spin Dryer-B (SRD-B)           | P2-01000 | Clean            | Dry the wafer automatically |   |
| Clean         |          | 3.3         |             | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | FH 6400L: 3krpm ( $\approx 1.5\mu m$ ), soft bake: $110^{\circ}\text{C}$ 1min |
| Clean         |          | 3.4         |             | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer       |   |
| Clean         |          | 3.5         |             | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: $120^{\circ}\text{C}$ , 1min                          |
| Clean         |          | 3.6         |             | CF-3000 Implanter (IMP-3000)   | P2-01000 | Clean Semi clean | Boron implant               | $1.93 \times 10^{12} \text{cm}^{-2}$ @40keV                                   |
| Clean         |          | 3.7         |             | PS210 Asher (DRY-PR-1)         | P2-01000 | Clean            | Resist strip                |   |
| Clean         |          | 3.8         |             | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Resist strip                |   |
| Clean         |          | 3.9         |             | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |   |

4 P-Base



| Wafer<br>ness | Cleanli- | Step<br>ber | Num-<br>ber | Equipment                      | Location | Cleanliness      | Process                     | Requirements  |
|---------------|----------|-------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean         |          | 4.1         |             | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean            | Default cleaning            |   |
| Clean         |          | 4.2         |             | Spin Dryer-B (SRD-B)           | P2-01000 | Clean            | Dry the wafer automatically |   |
| Clean         |          | 4.3         |             | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | FH 6400L: 3krpm ( $\approx 1.5\mu m$ ), soft bake: $110^{\circ}\text{C}$ 1min |
| Clean         |          | 4.4         |             | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer       |   |
| Clean         |          | 4.5         |             | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: $120^{\circ}\text{C}$ , 1min                          |
| Clean         |          | 4.6         |             | CF-3000 Implanter (IMP-3000)   | P2-01000 | Clean Semi clean | Boron implant               | $1.93 \times 10^{12} \text{cm}^{-2}$ @40keV                                   |
| Clean         |          | 4.7         |             | PS210 Asher (DRY-PR-1)         | P2-01000 | Clean            | Resist strip                |   |
| Clean         |          | 4.8         |             | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Resist strip                |   |
| Clean         |          | 4.9         |             | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |   |

5 N-Base



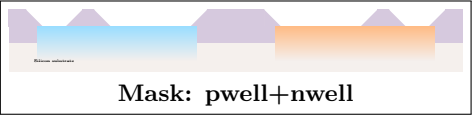
| Wafer<br>ness | Cleanli-<br>ness | Step<br>ber | Num-<br>ber | Equipment                      | Location | Cleanliness      | Process                     | Requirements   |
|---------------|------------------|-------------|-------------|--------------------------------|----------|------------------|-----------------------------|--|
|               | Clean            | 5.1         |             | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean            | Default cleaning            |  |
|               | Clean            | 5.2         |             | Spin Dryer-B (SRD-B)           | P2-01000 | Clean            | Dry the wafer automatically |  |
|               | Clean            | 5.3         |             | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | FH 6400L: 3krpm ( $\approx 1.5\mu m$ ), soft bake: $110^{\circ}C$ 1min |
|               | Clean            | 5.4         |             | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
|               | Clean            | 5.5         |             | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: $120^{\circ}C$ , 1min                          |
|               | Clean            | 5.6         |             | CF-3000 Implanter (IMP-3000)   | P2-01000 | Clean Semi clean | Phorphorus implant          | $2.33 \times 10^{12} cm^{-2}$ @110keV                                  |
|               | Clean            | 5.7         |             | PS210 Asher (DRY-PR-1)         | P2-01000 | Clean            | Resist strip                |  |
|               | Clean            | 5.8         |             | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Resist strip                |  |
|               | Clean            | 5.9         |             | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |

6 Shallow trench isolation



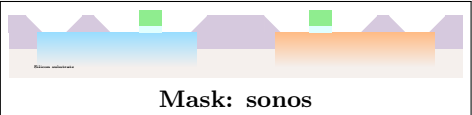
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|---------------|------------------|-------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
|               | Clean            | 6.1         |             | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean            | Default cleaning            |   |
|               | Clean            | 6.2         |             | Spin Dryer-B (SRD-B)           | P2-01000 | Clean            | Dry the wafer automatically |   |
|               | Clean            | 6.3         |             | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: $110^{\circ}C$ 1min |
|               | Clean            | 6.4         |             | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer       |   |
|               | Clean            | 6.5         |             | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: $120^{\circ}C$ , 1min                         |
|               | Clean            | 6.6         |             | DRIE Etcher #1 (DRY-Si-1)      | P2-01000 | Clean            | Etching the trenches        | 1 minute ( $2\mu m$ )   |
|               | Clean            | 6.7         |             | PS210 Asher (DRY-PR-1)         | P2-01000 | Clean            | Resist strip                |   |
|               | Clean            | 6.8         |             | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Resist strip                |   |
|               | Clean            | 6.9         |             | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |   |

7 Field oxide



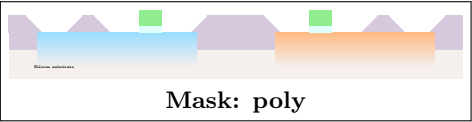
| Wafer<br>ness | Cleanli-<br>ness | Step<br>ber | Num-<br>ber | Equipment  | Location | Cleanliness      | Process                     | Requirements                                     |
|---------------|------------------|-------------|-------------|--|----------|------------------|-----------------------------|--|
| 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            | Drive in                    | 4 hours 30 minutes @ 1050°C in dry environment   |
| Clean         |                  | 7.4         |             | A3:Sulfuric cleaning (WET-A3)                    | P2-01000 | Clean            | Default cleaning            |  |
| Clean         |                  | 7.5         |             | Spin Dryer-A (SRD-A)                             | P2-01000 | Clean            | Dry the wafer automatically |  |
| Clean         |                  | 7.6         |             | LPCVD-B3 LTO (CVD-B3)                            | P2-01000 | Clean            | Oxide deposition            | 3μm (filling the trenches)                       |
| Clean         |                  | 7.7         |             | SVG Coater Track (PHT-T1)                        | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( ≈1.5μm ), soft bake: 110°C 1min |
| Clean         |                  | 7.8         |             | ASML Stepper (PHT-S1)                            | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
| Clean         |                  | 7.9         |             | SVG Developer Track (PHT-T2)                     | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min             |
| Clean         |                  | 7.10        |             | C3:BOE (WET-C3)                                  | P2-01000 | Clean            | BOE: Field oxide etching    | 6 minutes (3000 nm, 500nm/min)                   |
| Clean         |                  | 7.11        |             | E4:Resist strip (WET-E4)                         | P2-01000 | Clean Semi clean | Sulfuric resist strip       | H2SO4+H2O2, 120°C , 10mins                       |
| Clean         |                  | 7.12        |             | Spin Dryer-E (SRD-E)                             | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |

8 SONOS



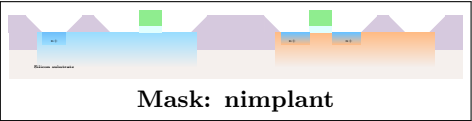
| Wafer<br>ness | Cleanli-<br>ness | Step<br>ber | Num-<br>ber | Equipment                                    | Location | Cleanliness      | Process                        | Requirements                                     |
|---------------|------------------|-------------|-------------|--|----------|------------------|--------------------------------|--|
| 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-B2 Nitride/Low-Stress Nitride (CVD-B2) | P2-01000 | Clean            | Lower gate oxide growth        | 40nm   |
| Clean         |                  | 8.4         |             | A3:Sulfuric cleaning (WET-A3)                | P2-01000 | Clean            | Default cleaning               |  |
| Clean         |                  | 8.5         |             | Spin Dryer-A (SRD-A)                         | P2-01000 | Clean            | Dry the wafer automatically    |  |
| Clean         |                  | 8.6         |             | LPCVD-B2 Nitride/Low-Stress Nitride (CVD-B2) | P2-01000 | Clean            | Charge carrying nitride growth | 10nm   |
| Clean         |                  | 8.7         |             | SVG Coater Track (PHT-T1)                    | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake    | HPR 504: 3krpm ( ≈1.5μm ), soft bake: 110°C 1min |
| Clean         |                  | 8.8         |             | ASML Stepper (PHT-S1)                        | P2-00100 | Clean Semi clean | Exposure of the layer          |  |
| Clean         |                  | 8.9         |             | SVG Developer Track (PHT-T2)                 | P2-00100 | Clean Semi clean | Develop, Hard bake             | FHD-5, 1min; hard bake: 120°C , 1min             |
| Clean         |                  | 8.10        |             | Lam 490 etcher (DRY-490)                     | P2-01000 | Clean            | Nitride etch                   | 6 seconds (10nm, 100nm/min)                      |
| Clean         |                  | 8.11        |             | C3:BOE (WET-C3)                              | P2-01000 | Clean            | BOE: Field oxide etching       | (4.8 seconds) ≈ 5 seconds (40 nm, 500nm/min)     |
| Clean         |                  | 8.12        |             | E4:Resist strip (WET-E4)                     | P2-01000 | Clean Semi clean | Sulfuric resist strip          | H2SO4+H2O2, 120°C , 10mins                       |
| Clean         |                  | 8.13        |             | Spin Dryer-E (SRD-E)                         | P2-01000 | Clean Semi clean | Dry the wafer automatically    |  |

9 Gate



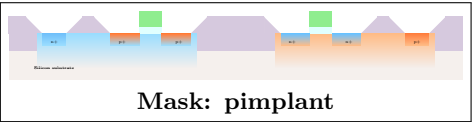
| Wafer-ness | Cleanli- | Step-ber | Num- | Equipment                                    | Location | Cleanliness      | Process                     | Requirements   |
|------------|----------|----------|------|--|----------|------------------|-----------------------------|--|
| Clean      |          | 9.1      |      | A3:Sulfuric cleaning (WET-A3)                | P2-01000 | Clean            | Default cleaning            |  |
| Clean      |          | 9.2      |      | Spin Dryer-A (SRD-A)                         | P2-01000 | Clean            | Dry the wafer automatically |  |
| Clean      |          | 9.3      |      | Diffusion Furnace-D2, dry oxidation (DIF-D1) | P2-01000 | Clean            | Gate oxide growth           | 40nm, 33 minutes 14 seconds @ 1050°C in dry environment      |
| Clean      |          | 9.4      |      | A3:Sulfuric cleaning (WET-A3)                | P2-01000 | Clean            | Default cleaning            |  |
| Clean      |          | 9.5      |      | Spin Dryer-A (SRD-A)                         | P2-01000 | Clean            | Dry the wafer automatically |  |
| Clean      |          | 9.6      |      | LPCVD-A3: Amor-Si/Poly (CVD-A3)              | P2-01000 | Clean            | Gate electrode growth       | 600nm of poly silicon  |
| Clean      |          | 9.7      |      | SVG Coater Track (PHT-T1)                    | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Clean      |          | 9.8      |      | ASML Stepper (PHT-S1)                        | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
| Clean      |          | 9.9      |      | SVG Developer Track (PHT-T2)                 | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                         |
| Clean      |          | 9.10     |      | Poly etcher (DRY-Poly)                       | P2-01000 | Clean Semi clean | Poly silicon etch           | 6 minute 10 seconds (600nm poly + 40nm oxide)                |
| Clean      |          | 9.11     |      | E4:Resist strip (WET-E4)                     | P2-01000 | Clean Semi clean | Sulfuric resist strip       | H2SO4+H2O2, 120°C , 10mins                                   |
| Clean      |          | 9.12     |      | Spin Dryer-E (SRD-E)                         | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |

10 N+ implant



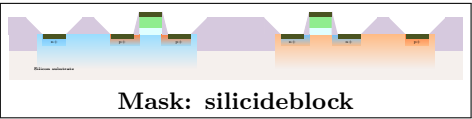
| Wafer-ness | Cleanli- | Step-ber | Num- | Equipment                      | Location | Cleanliness      | Process                     | Requirements  |
|------------|----------|----------|------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean      |          | 10.1     |      | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean            | Default cleaning            |   |
| Clean      |          | 10.2     |      | Spin Dryer-B (SRD-B)           | P2-01000 | Clean            | Dry the wafer automatically |   |
| Clean      |          | 10.3     |      | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | FH 6400L: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Clean      |          | 10.4     |      | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer       |   |
| Clean      |          | 10.5     |      | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                          |
| Clean      |          | 10.6     |      | CF-3000 Implanter (IMP-3000)   | P2-01000 | Clean Semi clean | Phosphorus implant          | $2.5 \times 10^{12} cm^{-2}$ @ 90keV                          |
| Clean      |          | 10.7     |      | PS210 Asher (DRY-PR-1)         | P2-01000 | Clean            | Resist strip                |   |
| Clean      |          | 10.8     |      | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Resist strip                |   |
| Clean      |          | 10.9     |      | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |   |

11 P+ implant



| Wafer<br>ness | Cleanli-<br>ness | Step<br>ber | Num-<br>ber | Equipment                      | Location | Cleanliness      | Process                     | Requirements  |
|---------------|------------------|-------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
|               | Clean            | 11.1        |             | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean            | Default cleaning            |   |
|               | Clean            | 11.2        |             | Spin Dryer-B (SRD-B)           | P2-01000 | Clean            | Dry the wafer automatically |   |
|               | Clean            | 11.3        |             | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | FH 6400L: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
|               | Clean            | 11.4        |             | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer       |   |
|               | Clean            | 11.5        |             | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                          |
|               | Clean            | 11.6        |             | CF-3000 Implanter (IMP-3000)   | P2-01000 | Clean Semi clean | Boron implant               | $2.5 \times 10^{12} cm^{-2}$ @ 35keV                          |
|               | Clean            | 11.7        |             | PS210 Asher (DRY-PR-1)         | P2-01000 | Clean            | Resist strip                |   |
|               | Clean            | 11.8        |             | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Resist strip                |   |
|               | Clean            | 11.9        |             | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |   |

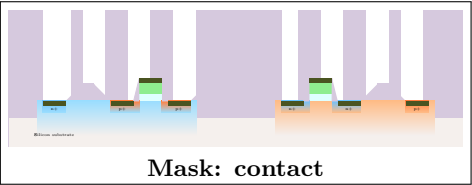
12 Silicification



| Wafer<br>ness | Cleanli-<br>ness | Step<br>ber | Num-<br>ber | Equipment                      | Location | Cleanliness      | Process                     | Requirements   |
|---------------|------------------|-------------|-------------|--------------------------------|----------|------------------|-----------------------------|--|
|               | Clean            | 12.1        |             | A3:Sulfuric cleaning (WET-A3)  | P2-01000 | Clean            | Default cleaning            |  |
|               | Clean            | 12.2        |             | Spin Dryer-A (SRD-A)           | P2-01000 | Clean            | Dry the wafer automatically |  |
|               | Clean            | 12.3        |             | LPCVD-B3 LTO (CVD-B3)          | P2-01000 | Clean            | Spacer oxide                | 50 nm  |
|               | Clean            | 12.4        |             | SVG Coater Track (PHT-T1)      | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min   |
|               | Clean            | 12.5        |             | ASML Stepper (PHT-S1)          | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
|               | Clean            | 12.6        |             | SVG Developer Track (PHT-T2)   | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                           |
|               | Clean            | 12.7        |             | AOE Etcher (DRY-AOE)           | P2-01000 | Clean            | Anisotropic oxide etch      | 12 seconds   |
|               | Clean            | 12.8        |             | E4:Resist strip (WET-E4)       | P2-01000 | Clean Semi clean | Sulfuric resist strip       | H2SO4+H2O2, 120°C , 10mins                                     |
|               | Clean            | 12.9        |             | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |
|               | Semi clean       | 12.10       |             | Varian 3180 Sputter (SPT-3180) | P2-01000 | Semi clean       | Deposit Titanium            | 15 seconds (roughly 60nm)                                      |
|               | Semi clean       | 12.11       |             | AG610 RTP (DIF-R2)             | P2-01000 | Semi clean       | First reaction phase        | 240 seconds @ 700°C  |
|               | Semi clean       | 12.12       |             | E2: General purpose (WET-E2)   | P2-01000 | Semi clean       | Remove unreacted Titanium   | APM solution (Ammonia and Hydrogen Peroxide mixture), 1 minute |
|               | Semi clean       | 12.13       |             | Spin Dryer-E (SRD-E)           | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |
|               | Semi clean       | 12.14       |             | AG610 RTP (DIF-R2)             | P2-01000 | Semi clean       | Second reaction phase       | 240 seconds @ 800°C  |

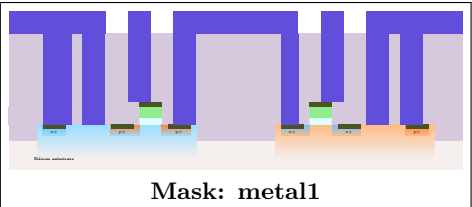


13 Contact



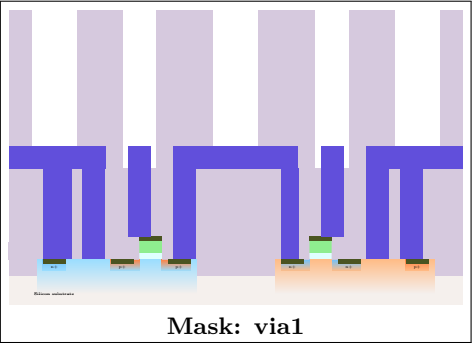
| Wafer Cleanli-ness | Step Num-ber | Equipment                       | Location | Cleanliness      | Process                     | Requirements   |
|--------------------|--------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean         | 13.1         | D1: Dump rinse (WET-D-DR)       | P2-01000 | Semi clean       | Wafer cleaning              |  |
| Semi clean         | 13.2         | Spin Dryer-D (SRD-D)            | P2-01000 | Semi clean       | Dry the wafer automatically |  |
| Semi clean         | 13.3         | LPCVD-F4 LTO/PSG (CVD-F4)       | P2-01000 | Semi clean       | Oxide deposition            | 500 nm   |
| Semi clean         | 13.4         | SVG Coater Track (PHT-T1)       | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Semi clean         | 13.5         | ASML Stepper (PHT-S1)           | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
| Semi clean         | 13.6         | SVG Developer Track (PHT-T2)    | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                         |
| Semi clean         | 13.7         | E2: General purpose (WET-E2)    | P2-01000 | Semi clean       | BOE (1:6), LTO Etch         | 1 minute (500 nm, 500nm/min)                                 |
| Semi clean         | 13.8         | Spin Dryer-E (SRD-E)            | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |
| Semi clean         | 13.9         | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean       | Resist Stripping            | 5mins, 70°C  |
| Semi clean         | 13.10        | Spin Dryer-Y (SRD-Y)            | P2-00100 | Semi clean       | Spin dry                    |  |

14 Metal 1



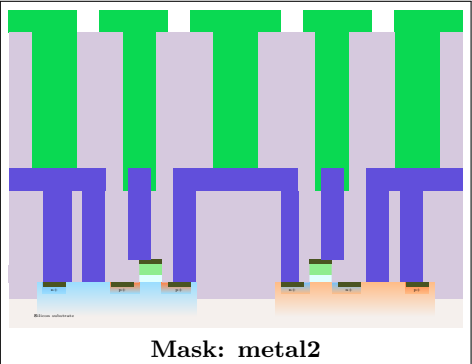
| Wafer Cleanli-ness | Step Num-ber | Equipment                       | Location | Cleanliness      | Process                     | Requirements   |
|--------------------|--------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean         | 14.1         | Varian 3180 Sputter (SPT-3180)  | P2-01000 | Semi clean       | Deposit Aluminum            | 37.5 seconds (roughly 600nm)                                 |
| Semi clean         | 14.2         | SVG Coater Track (PHT-T1)       | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Semi clean         | 14.3         | ASML Stepper (PHT-S1)           | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
| Semi clean         | 14.4         | SVG Developer Track (PHT-T2)    | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                         |
| Semi clean         | 14.5         | D1: Aluminum etch (WET-D1)      | P2-01000 | Semi clean       | Wire formation              | 2 minutes (600 nm, 282.3 nm/min)                             |
| Semi clean         | 14.6         | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean       | Resist Stripping            | 5mins, 70°C  |
| Semi clean         | 14.7         | Spin Dryer-Y (SRD-Y)            | P2-00100 | Semi clean       | Spin dry                    |  |

15 Via 1



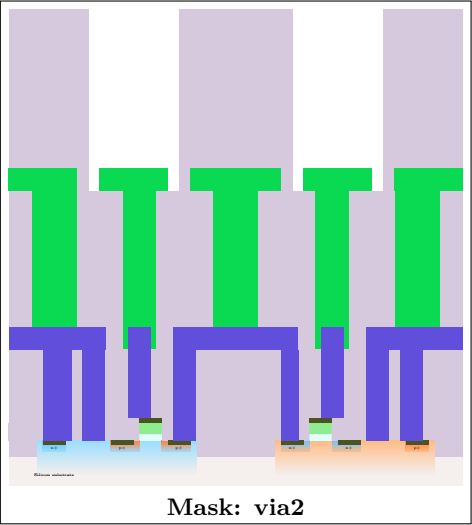
| Wafer Cleanli-ness | Step Num-ber | Equipment                       | Location | Cleanliness      | Process                     | Requirements   |
|--------------------|--------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean         | 15.1         | D1: Dump rinse (WET-D-DR)       | P2-01000 | Semi clean       | Wafer cleaning              |  |
| Semi clean         | 15.2         | Spin Dryer-D (SRD-D)            | P2-01000 | Semi clean       | Dry the wafer automatically |  |
| Semi clean         | 15.3         | LPCVD-F4 LTO/PSG (CVD-F4)       | P2-01000 | Semi clean       | Oxide deposition            | 500 nm   |
| Semi clean         | 15.4         | SVG Coater Track (PHT-T1)       | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Semi clean         | 15.5         | ASML Stepper (PHT-S1)           | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
| Semi clean         | 15.6         | SVG Developer Track (PHT-T2)    | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                         |
| Semi clean         | 15.7         | E2: General purpose (WET-E2)    | P2-01000 | Semi clean       | BOE (1:6), LTO Etch         | 1 minute (500 nm, 500nm/min)                                 |
| Semi clean         | 15.8         | Spin Dryer-E (SRD-E)            | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |
| Semi clean         | 15.9         | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean       | Resist Stripping            | 5mins, 70°C  |
| Semi clean         | 15.10        | Spin Dryer-Y (SRD-Y)            | P2-00100 | Semi clean       | Spin dry                    |  |

16 Metal 2



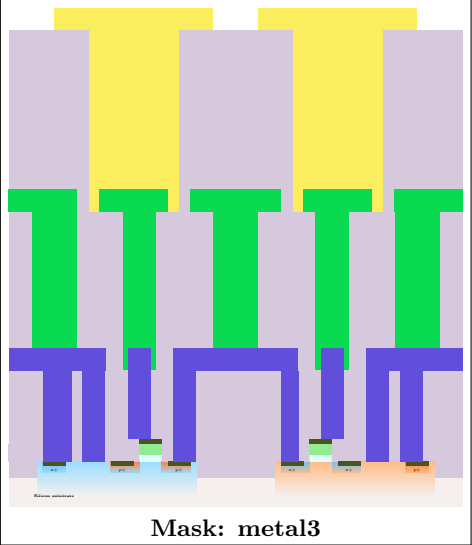
| Wafer Cleanli-ness | Step Num-ber | Equipment                       | Location | Cleanliness      | Process                     | Requirements   |
|--------------------|--------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean         | 16.1         | Varian 3180 Sputter (SPT-3180)  | P2-01000 | Semi clean       | Deposit Aluminum            | 37.5 seconds (roughly 600nm)                                 |
| Semi clean         | 16.2         | SVG Coater Track (PHT-T1)       | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Semi clean         | 16.3         | ASML Stepper (PHT-S1)           | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
| Semi clean         | 16.4         | SVG Developer Track (PHT-T2)    | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                         |
| Semi clean         | 16.5         | D1: Aluminum etch (WET-D1)      | P2-01000 | Semi clean       | Wire formation              | 2 minutes (600 nm, 282.3 nm/min)                             |
| Semi clean         | 16.6         | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean       | Resist Stripping            | 5mins, 70°C  |
| Semi clean         | 16.7         | Spin Dryer-Y (SRD-Y)            | P2-00100 | Semi clean       | Spin dry                    |  |

17 Via 2



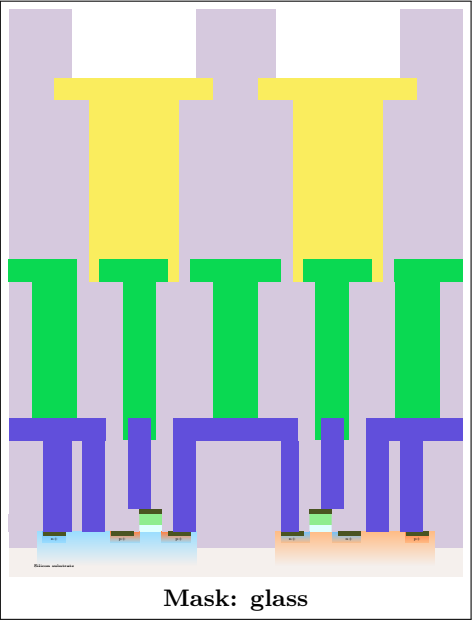
| Wafer Cleanli-ness | Step Num-ber | Equipment                       | Location | Cleanliness      | Process                     | Requirements   |
|--------------------|--------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean         | 17.1         | D1: Dump rinse (WET-D-DR)       | P2-01000 | Semi clean       | Wafer cleaning              |  |
| Semi clean         | 17.2         | Spin Dryer-D (SRD-D)            | P2-01000 | Semi clean       | Dry the wafer automatically |  |
| Semi clean         | 17.3         | LPCVD-F4 LTO/PSG (CVD-F4)       | P2-01000 | Semi clean       | Oxide deposition            | 500 nm   |
| Semi clean         | 17.4         | SVG Coater Track (PHT-T1)       | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| Semi clean         | 17.5         | ASML Stepper (PHT-S1)           | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
| Semi clean         | 17.6         | SVG Developer Track (PHT-T2)    | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                         |
| Semi clean         | 17.7         | E2: General purpose (WET-E2)    | P2-01000 | Semi clean       | BOE (1:6), LTO Etch         | 1 minute (500 nm, 500nm/min)                                 |
| Semi clean         | 17.8         | Spin Dryer-E (SRD-E)            | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |
| Semi clean         | 17.9         | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean       | Resist Stripping            | 5mins, 70°C  |
| Semi clean         | 17.10        | Spin Dryer-Y (SRD-Y)            | P2-00100 | Semi clean       | Spin dry                    |  |

18 Metal 3



| Wafer Cleanli-ness | Step Num-ber | Equipment                       | Location | Cleanliness      | Process  | Requirements   |
|--------------------|--------------|---------------------------------|----------|------------------|--|--|
| Semi clean         | 18.1         | NSC3000 Sputter (SPT-NSC3000)   | P2-01000 | Semi clean       | Deposit Titanium-Tungsten alloy (TiW -> 5nm/min) | 120 minutes = 2 hours (roughly 600nm)                            |
| Semi clean         | 18.2         | SVG Coater Track (PHT-T1)       | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake                      | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min     |
| Semi clean         | 18.3         | ASML Stepper (PHT-S1)           | P2-00100 | Clean Semi clean | Exposure of the layer                            |  |
| Semi clean         | 18.4         | SVG Developer Track (PHT-T2)    | P2-00100 | Clean Semi clean | Develop, Hard bake                               | FHD-5, 1min; hard bake: 120°C , 1min                             |
| Semi clean         | 18.5         | E2: General purpose (WET-E2)    | P2-01000 | Semi clean       | Wire formation                                   | APM solution (Ammonia and Hydrogen Peroxide mixture), 10 minutes |
| Semi clean         | 18.6         | Spin Dryer-E (SRD-E)            | P2-01000 | Clean Semi clean | Dry the wafer automatically                      |  |
| Semi clean         | 18.7         | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean       | Resist Stripping                                 | 5mins, 70°C  |
| Semi clean         | 18.8         | Spin Dryer-Y (SRD-Y)            | P2-00100 | Semi clean       | Spin dry   |  |

19 Glass



| Wafer | Cleanli-<br>ness |
|-------|------------------|
|       | Semi clean       |
|       | Semi clean       |
|       | Semi clean       |
|       | Semi clean       |
|       | Semi clean       |
|       | Semi clean       |
|       | Semi clean       |
|       | Semi clean       |
|       | Semi clean       |
|       | Semi clean       |

| Step Num-<br>ber | Equipment                       | Location | Cleanliness      | Process                     | Requirements   |
|------------------|---------------------------------|----------|------------------|-----------------------------|--|
| 19.1             | D1: Dump rinse (WET-D-DR)       | P2-01000 | Semi clean       | Wafer cleaning              |  |
| 19.2             | Spin Dryer-D (SRD-D)            | P2-01000 | Semi clean       | Dry the wafer automatically |  |
| 19.3             | LPCVD-F4 LTO/PSG (CVD-F4)       | P2-01000 | Semi clean       | Oxide deposition            | 500 nm   |
| 19.4             | SVG Coater Track (PHT-T1)       | P2-00100 | Clean Semi clean | HMDS, PR coating, soft bake | HPR 504: 3krpm ( $\approx 1.5\mu m$ ), soft bake: 110°C 1min |
| 19.5             | ASML Stepper (PHT-S1)           | P2-00100 | Clean Semi clean | Exposure of the layer       |  |
| 19.6             | SVG Developer Track (PHT-T2)    | P2-00100 | Clean Semi clean | Develop, Hard bake          | FHD-5, 1min; hard bake: 120°C , 1min                         |
| 19.7             | E2: General purpose (WET-E2)    | P2-01000 | Semi clean       | BOE (1:6), LTO Etch         | 1 minute (500 nm, 500nm/min)                                 |
| 19.8             | Spin Dryer-E (SRD-E)            | P2-01000 | Clean Semi clean | Dry the wafer automatically |  |
| 19.9             | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean       | Resist Stripping            | 5mins, 70°C  |
| 19.10            | Spin Dryer-Y (SRD-Y)            | P2-00100 | Semi clean       | Spin dry                    |  |