

LibreSilicon process HKUST (NFF)

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July 10, 2019

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.

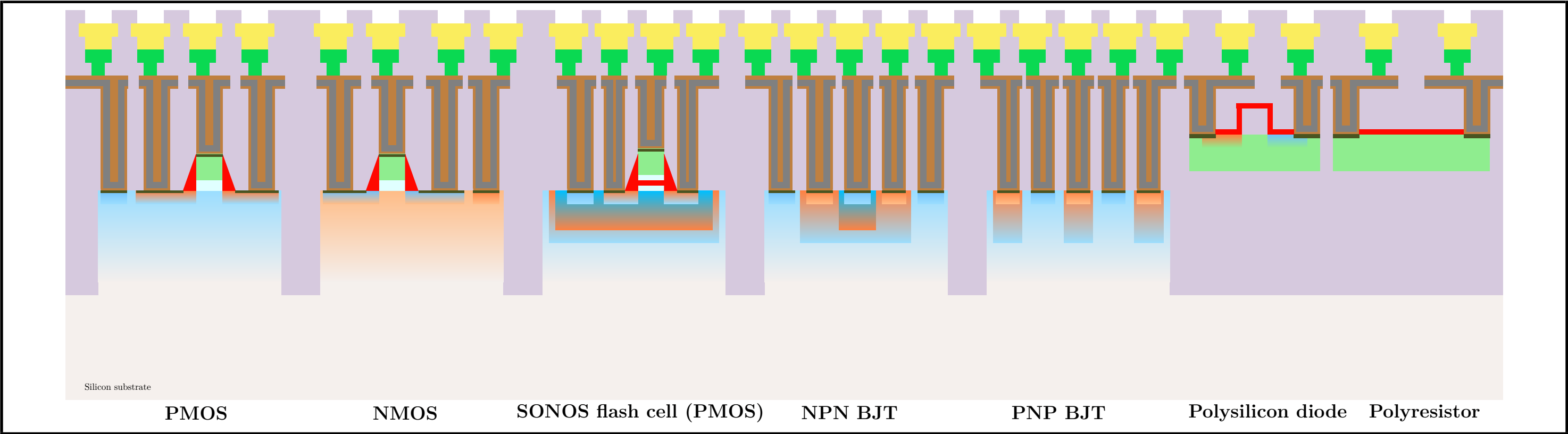
Please see the document with the generic steps² in order to get a detailed description of the different steps.

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

²https://github.com/libresilicon/process/raw/master/process_steps/process_hightech/process_hightech_steps.pdf

Process Flow of Lanceville Technologies LibreSilicon 1 μm

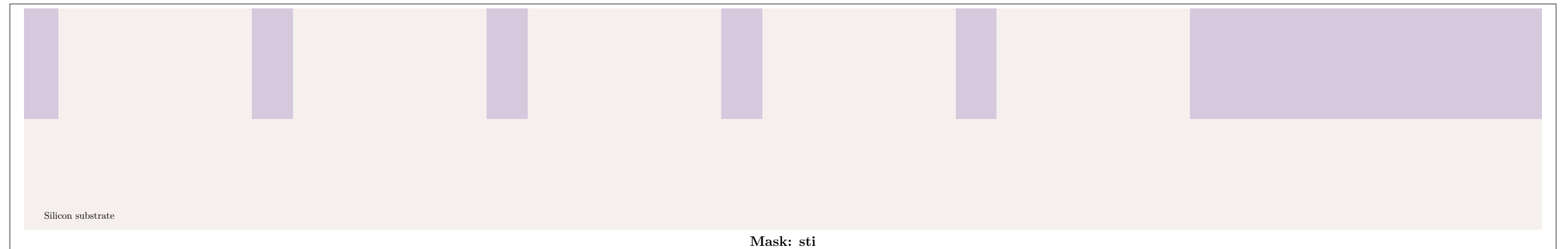
- Project: LibreSilicon 1 μm
- Name: Lanceville Technologies Group
- Substrate: P-Substrate silicon wafer <100>
- Date: July 10, 2019



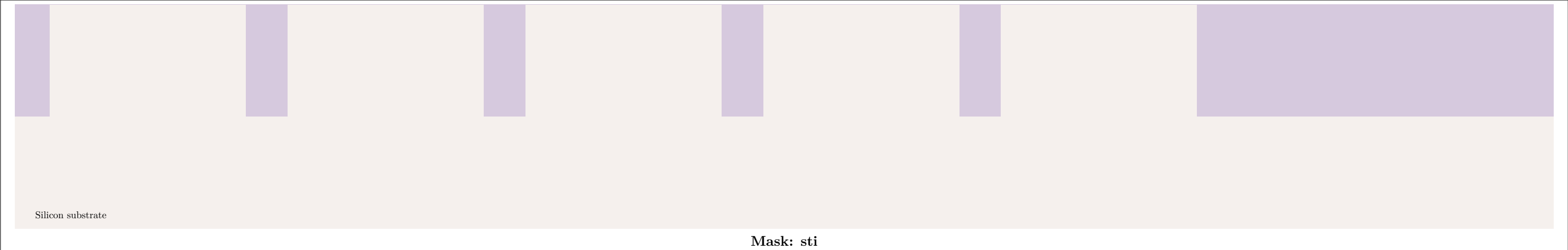
1 Initial alignment mask

| Silicon substrate | | | | | | |
|-------------------|-------------|--------------------------------|----------|------------------|-----------------------------|--|
| Mask: basic | | | | | | |
| Wafer Cleanliness | Step Number | 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 | $280mJcm^2$ |
| 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 | NFF RIE Etcher (DRY-RIE-2) | P2-01000 | Clean Semi clean | CF4 Etch | 140 seconds |
| 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 Shallow trench isolation

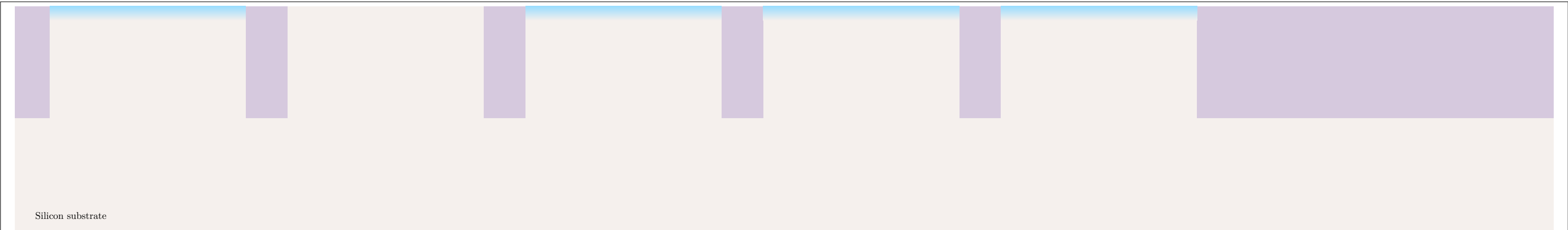


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--------------------------------|----------|------------------|-----------------------------|--|
| Clean | 2.1 | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean | Default 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 | HPR 504: 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 | $280mJcm^2$ |
| 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 | DRIE Etcher #1 (DRY-Si-1) | P2-01000 | Clean | Etching the trenches | Thin line recipe, $1\mu m$: 7 cycles -> 35 cycles |
| 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 | |
| Clean | 2.10 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |



| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|-------------------------------|----------|-------------|---------------------------------|--|
| Clean | 2.11 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 2.12 | LPCVD-B3 LTO (CVD-B3) | P2-01000 | Clean | Oxide deposition | 4μm LTO |
| Clean | 2.13 | Strasbaugh CMP (CMP-1) | P2-10000 | Clean | Planarize oxide down to silicon | Use oxide planarization slurry, 15 minutes |
| Clean | 2.14 | G1:TMAH (WET-G1) | P2-01000 | Clean | Ammonium cleaning | 70°C , 10mins |
| Clean | 2.15 | C3:BOE (WET-C3) | P2-01000 | Clean | HF dip | 1 minute |
| Clean | 2.16 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |
| Clean | 2.17 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 2.18 | LPCVD-B3 LTO (CVD-B3) | P2-01000 | Clean | Oxide deposition | 2μm LTO |
| Clean | 2.19 | Strasbaugh CMP (CMP-1) | P2-10000 | Clean | Planarize oxide down to silicon | Use oxide planarization slurry, 10 minutes |
| Clean | 2.20 | G1:TMAH (WET-G1) | P2-01000 | Clean | Ammonium cleaning | 70°C , 10mins |

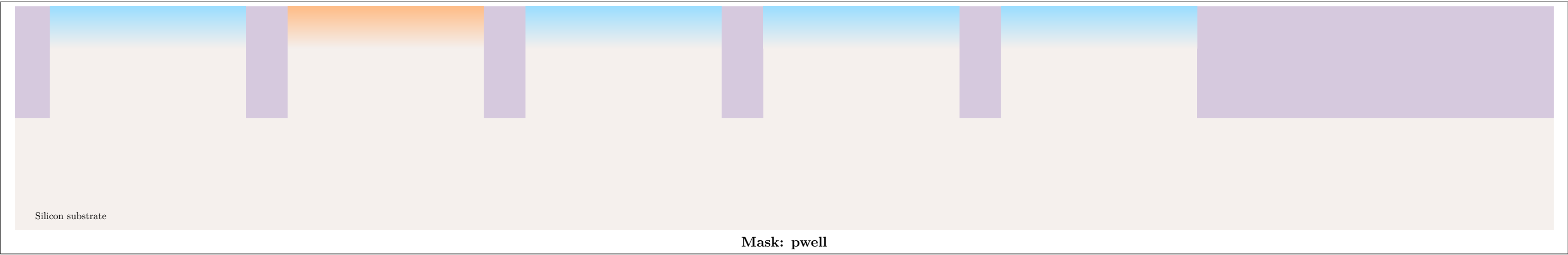
3 N-well



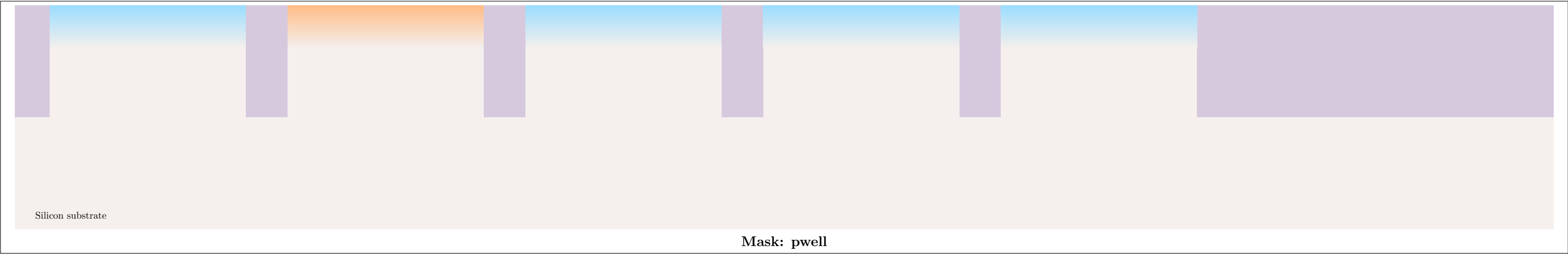
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| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean | 3.1 | B1: 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°C 1min |
| Clean | 3.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $340mJcm^2$ |
| Clean | 3.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 30min |
| Clean | 3.6 | CF-3000 Implanter (IMP-3000) | P2-01000 | Clean Semi clean | Phorphorus implant | $2.33 \times 10^{12}cm^{-2}@70keV$ |
| 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-well

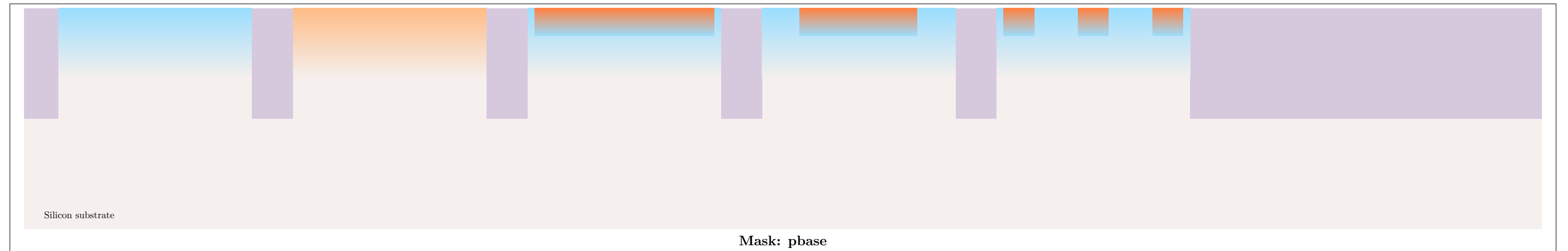


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean | 4.1 | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean | Default 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°C 1min |
| Clean | 4.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $340mJcm^2$ |
| Clean | 4.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 30min |
| Clean | 4.6 | CF-3000 Implanter (IMP-3000) | P2-01000 | Clean Semi clean | Boron implant | $1.93 \times 10^{12}cm^{-2}@40keV$ |
| 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 | |
| Clean | 4.10 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |

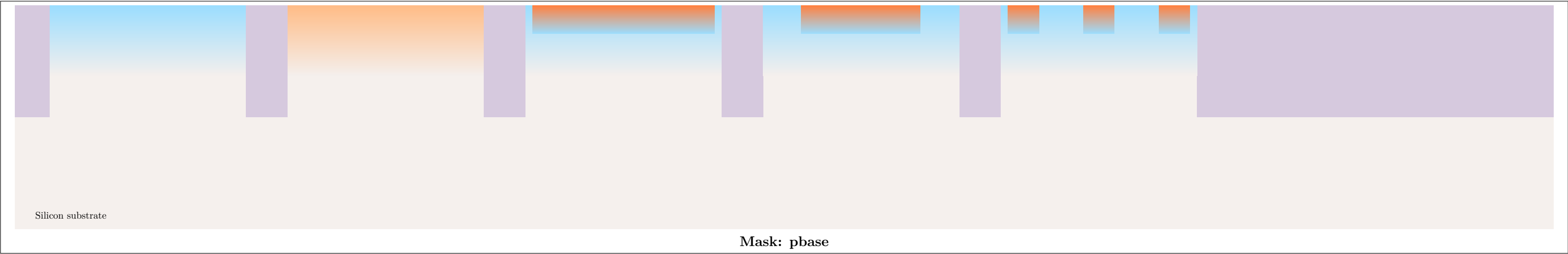


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---|----------|-------------|-----------------------------|---|
| Clean | 4.11 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 4.12 | Diffusion Furnace-A1, anneal/oxidation (DIF-A1) | P2-01000 | Clean | Drive in | 2 hours @ 1050°C in inert (N_2) environment |

5 P-Base

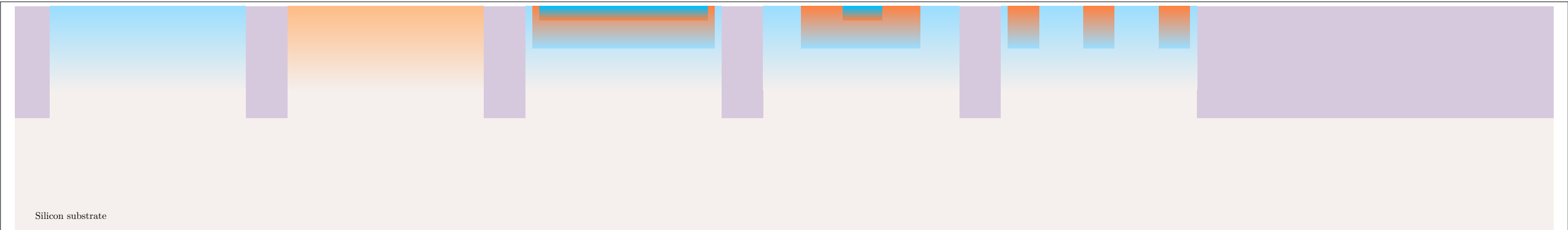


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean | 5.1 | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean | Default 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°C 1min |
| Clean | 5.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $340mJcm^2$ |
| Clean | 5.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 30min |
| Clean | 5.6 | CF-3000 Implanter (IMP-3000) | P2-01000 | Clean Semi clean | Boron implant | $1.93 \times 10^{12}cm^{-2}@40keV$ |
| 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 | |
| Clean | 5.10 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |



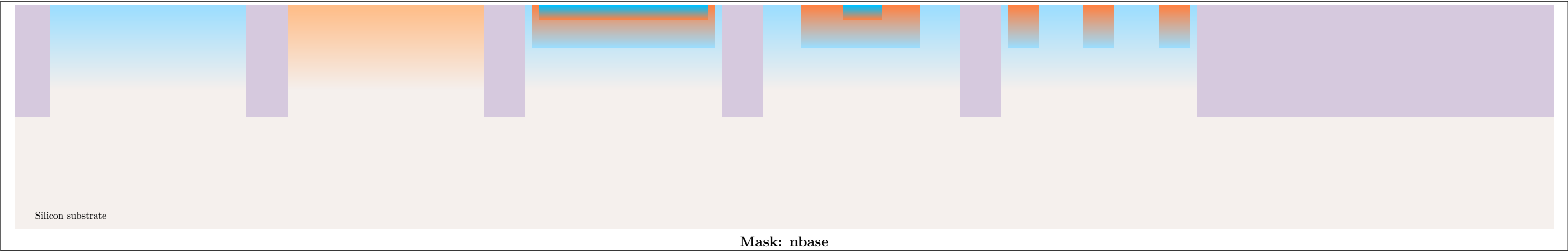
| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---|----------|-------------|-----------------------------|--|
| Clean | 5.11 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 5.12 | Diffusion Furnace-A1, anneal/oxidation (DIF-A1) | P2-01000 | Clean | Drive in | 1 hour @ 1050°C in inert (N_2) environment |

6 N-Base



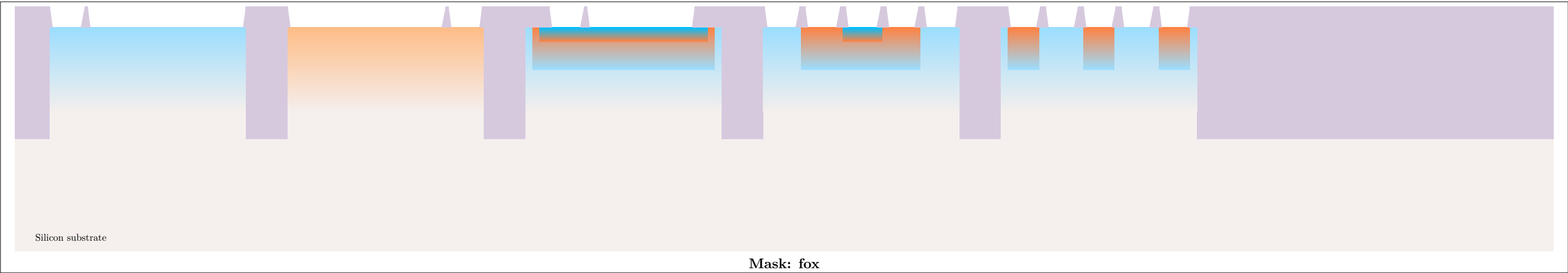
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| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean | 6.1 | B1: 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 | FH 6400L: 3krpm ($\approx 1.5\mu m$), soft bake: 110°C 1min |
| Clean | 6.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $340mJcm^2$ |
| Clean | 6.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 30min |
| Clean | 6.6 | CF-3000 Implanter (IMP-3000) | P2-01000 | Clean Semi clean | Phorphorus implant | $2.33 \times 10^{12}cm^{-2}@70keV$ |
| 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 | |
| Clean | 6.10 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |



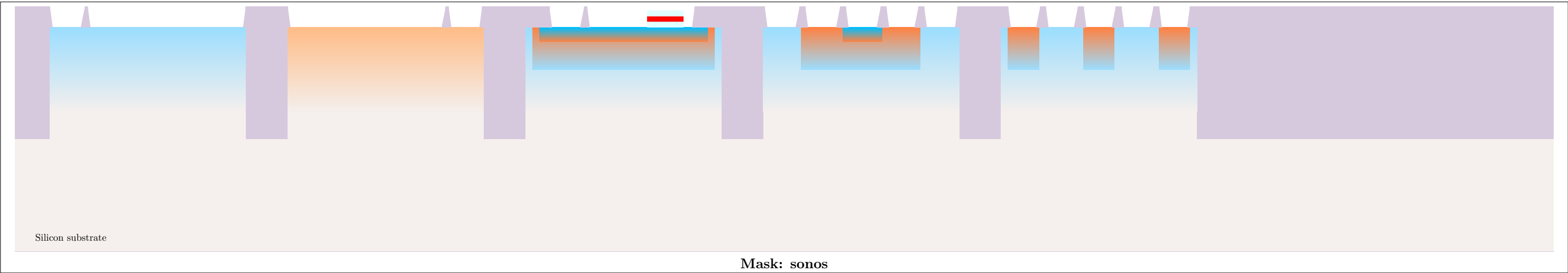
| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---|----------|-------------|-----------------------------|--|
| Clean | 6.11 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 6.12 | Diffusion Furnace-A1, anneal/oxidation (DIF-A1) | P2-01000 | Clean | Drive in | 30 minutes @ 1050°C in inert (N_2) environment |

7 Field oxide

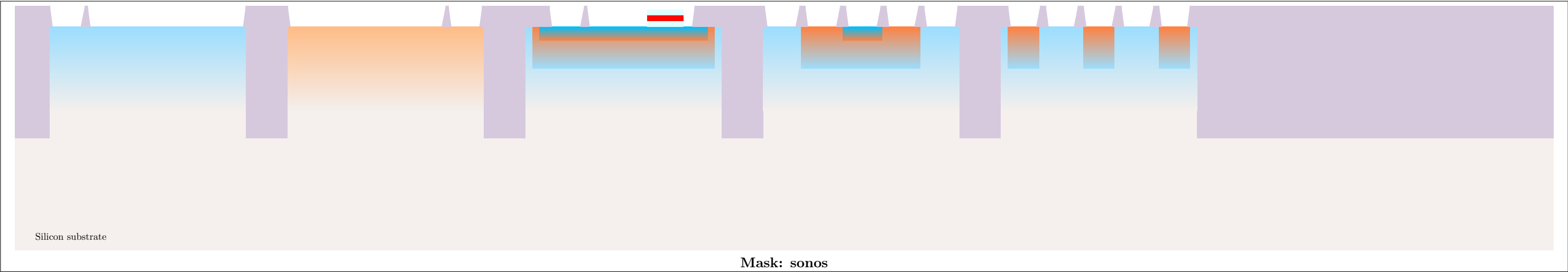


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|-------------------------------|----------|------------------|-----------------------------|--|
| Clean | 7.1 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |
| Clean | 7.2 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 7.3 | LPCVD-B3 LTO (CVD-B3) | P2-01000 | Clean | Oxide deposition | 200nm LTO |
| Clean | 7.4 | 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 | 7.5 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Clean | 7.6 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Clean | 7.7 | AOE Etcher (DRY-AOE) | P2-01000 | Clean | Etch oxide FOX openings | Etch through 200nm |
| Clean | 7.8 | PS210 Asher (DRY-PR-1) | P2-01000 | Clean | Resist strip | |
| Clean | 7.9 | E4:Resist strip (WET-E4) | P2-01000 | Clean Semi clean | Resist strip | |
| Clean | 7.10 | Spin Dryer-E (SRD-E) | P2-01000 | Clean Semi clean | Dry the wafer automatically | |

8 SONOS



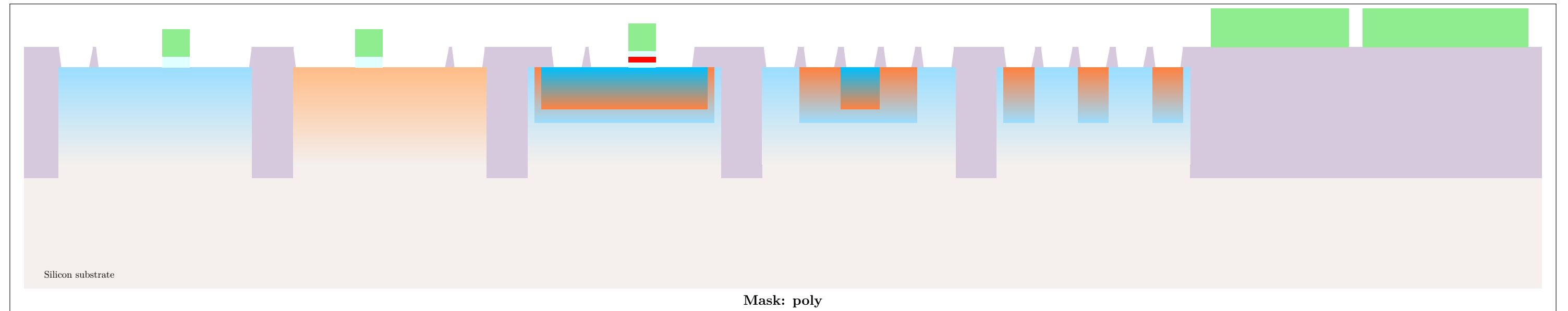
| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--|----------|------------------|--------------------------------|--|
| Clean | 8.1 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |
| Clean | 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 | Lower gate oxide growth | 5nm |
| 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 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |
| Clean | 8.8 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 8.9 | LPCVD-B3 LTO (CVD-B3) | P2-01000 | Clean | Lower gate oxide growth | 5nm |
| Clean | 8.10 | 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 |



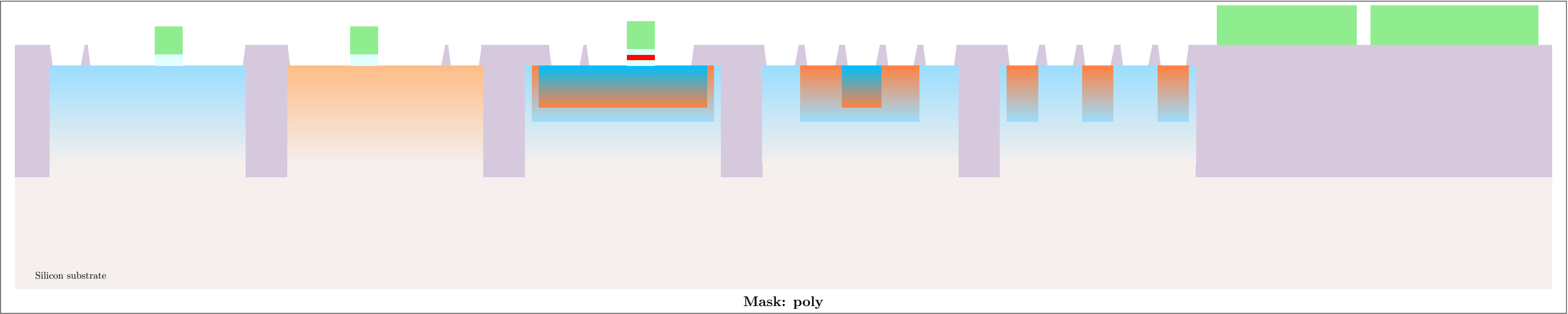
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| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|------------------------------|----------|------------------|-----------------------------|--------------------------------------|
| Clean | 8.11 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Clean | 8.12 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Clean | 8.13 | NFF RIE Etcher (DRY-RIE-2) | P2-01000 | Clean Semi clean | Nitride etch | 6 seconds (10nm, 100nm/min) |
| Clean | 8.14 | PS210 Asher (DRY-PR-1) | P2-01000 | Clean | Resist strip | |
| Clean | 8.15 | E4:Resist strip (WET-E4) | P2-01000 | Clean Semi clean | Resist strip | |
| Clean | 8.16 | Spin Dryer-E (SRD-E) | P2-01000 | Clean Semi clean | Dry the wafer automatically | |

9 Gate

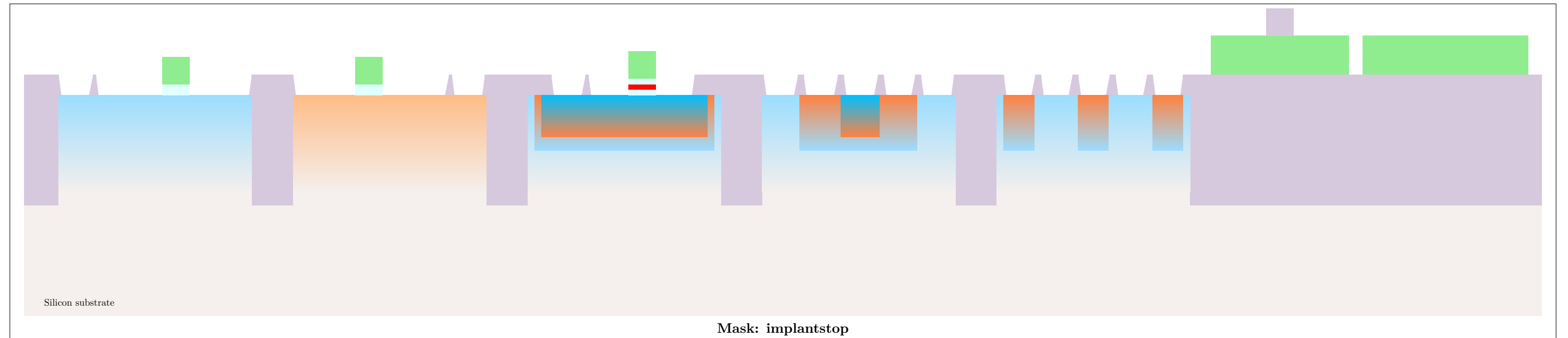


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---|----------|------------------|-----------------------------|--|
| Clean | 9.1 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |
| Clean | 9.2 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 9.3 | Diff. Furnace-D1 Dry Oxidation (Only for gate oxide) (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 | 250nm 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 | $280mJcm^2$ |
| 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 | HBr only, 2 minutes |



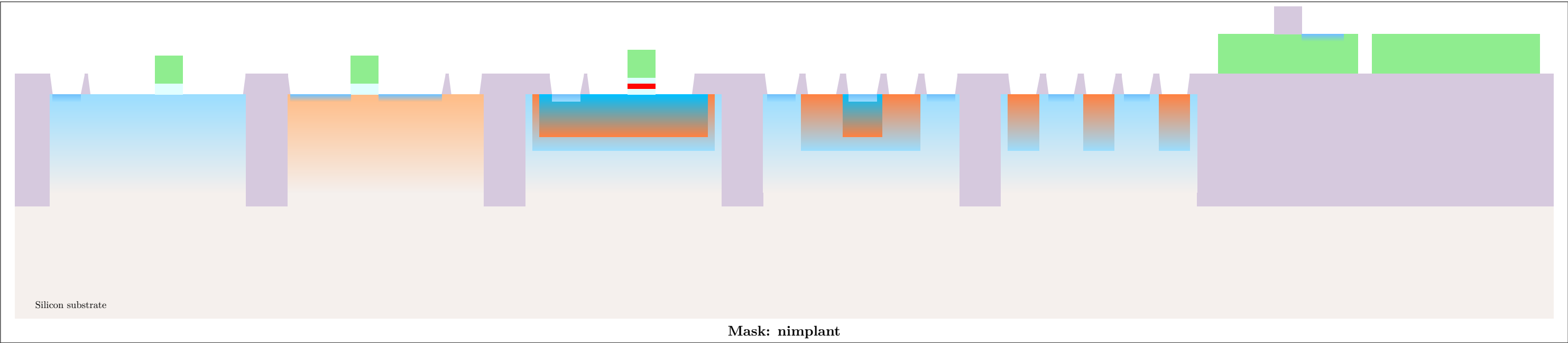
| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--------------------------|----------|------------------|-----------------------------|--------------|
| Clean | 9.11 | PS210 Asher (DRY-PR-1) | P2-01000 | Clean | Resist strip | |
| Clean | 9.12 | E4:Resist strip (WET-E4) | P2-01000 | Clean Semi clean | Resist strip | |
| Clean | 9.13 | Spin Dryer-E (SRD-E) | P2-01000 | Clean Semi clean | Dry the wafer automatically | |

10 Implant stop



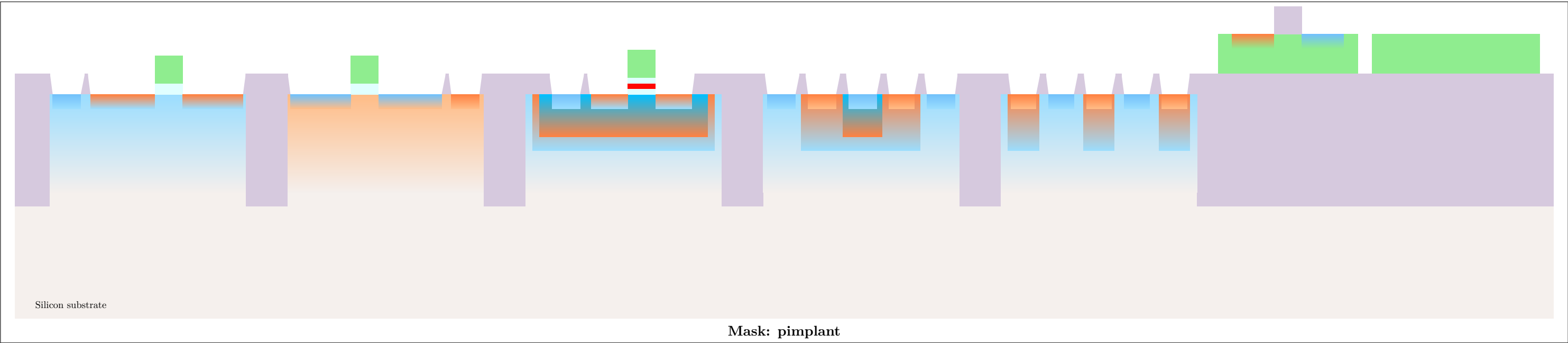
| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|-------------------------------|----------|------------------|-----------------------------|--|
| Clean | 10.1 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |
| Clean | 10.2 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 10.3 | LPCVD-B3 LTO (CVD-B3) | P2-01000 | Clean | Oxide deposition | 200nm LTO |
| Clean | 10.4 | 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 | 10.5 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Clean | 10.6 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Clean | 10.7 | NFF RIE Etcher (DRY-RIE-2) | P2-01000 | Clean Semi clean | CHF3 etch | 300 seconds |
| Clean | 10.8 | E4:Resist strip (WET-E4) | P2-01000 | Clean Semi clean | Sulfuric resist strip | H2SO4+H2O2, 120°C , 10mins |
| Clean | 10.9 | Spin Dryer-E (SRD-E) | P2-01000 | Clean Semi clean | Dry the wafer automatically | |

11 N+ implant

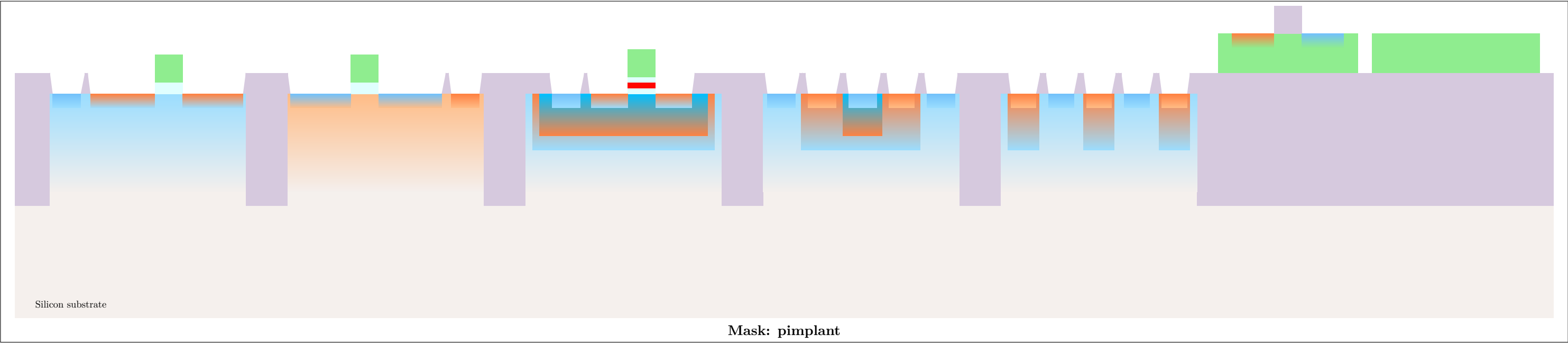


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean | 11.1 | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean | Default 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 | $340mJcm^2$ |
| Clean | 11.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 30min |
| Clean | 11.6 | CF-3000 Implanter (IMP-3000) | P2-01000 | Clean Semi clean | Phorphorus implant | $2.5 \times 10^{12}cm^{-2}$ @ 30keV |
| 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 P+ implant

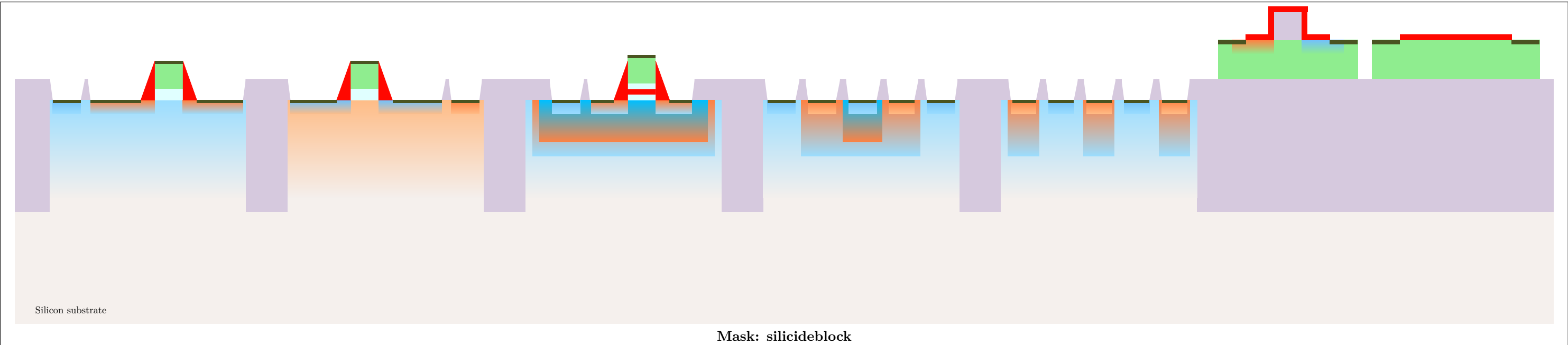


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--------------------------------|----------|------------------|-----------------------------|---|
| Clean | 12.1 | B1: Sulfuric cleaning (WET-B1) | P2-01000 | Clean | Default cleaning | |
| Clean | 12.2 | Spin Dryer-B (SRD-B) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 12.3 | 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 | 12.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $340mJcm^2$ |
| Clean | 12.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 30min |
| Clean | 12.6 | CF-3000 Implanter (IMP-3000) | P2-01000 | Clean Semi clean | Boron implant | $2.5 \times 10^{12}cm^{-2}$ @ 20keV |
| Clean | 12.7 | PS210 Asher (DRY-PR-1) | P2-01000 | Clean | Resist strip | |
| Clean | 12.8 | E4:Resist strip (WET-E4) | P2-01000 | Clean Semi clean | Resist strip | |
| Clean | 12.9 | Spin Dryer-E (SRD-E) | P2-01000 | Clean Semi clean | Dry the wafer automatically | |
| Clean | 12.10 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |



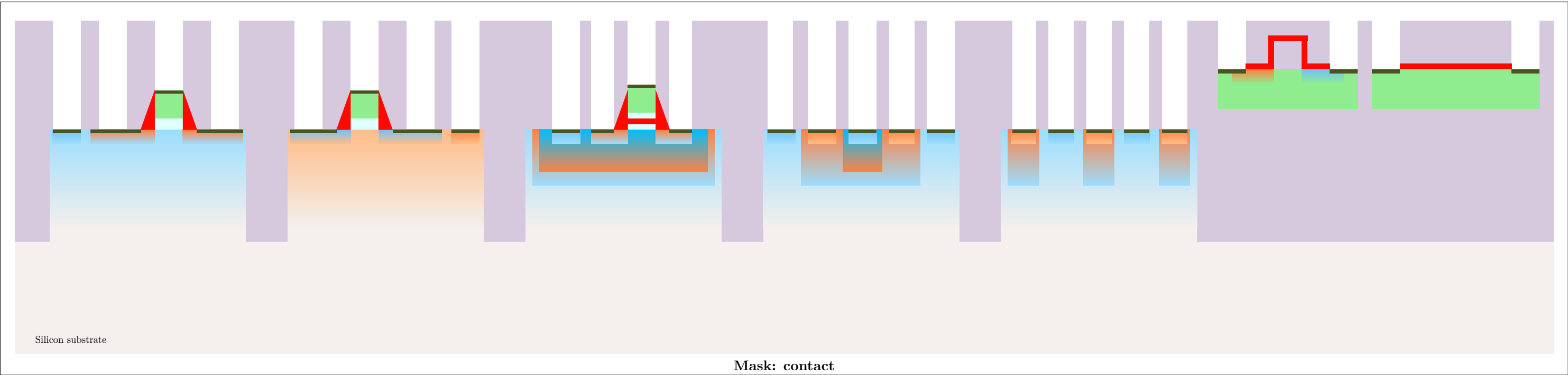
| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---|----------|-------------|-----------------------------|---|
| Clean | 12.11 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 12.12 | Diffusion Furnace-A1, anneal/oxidation (DIF-A1) | P2-01000 | Clean | Drive in | 30 minutes @ 900°C , drive in + dry oxidation |

13 Silicification



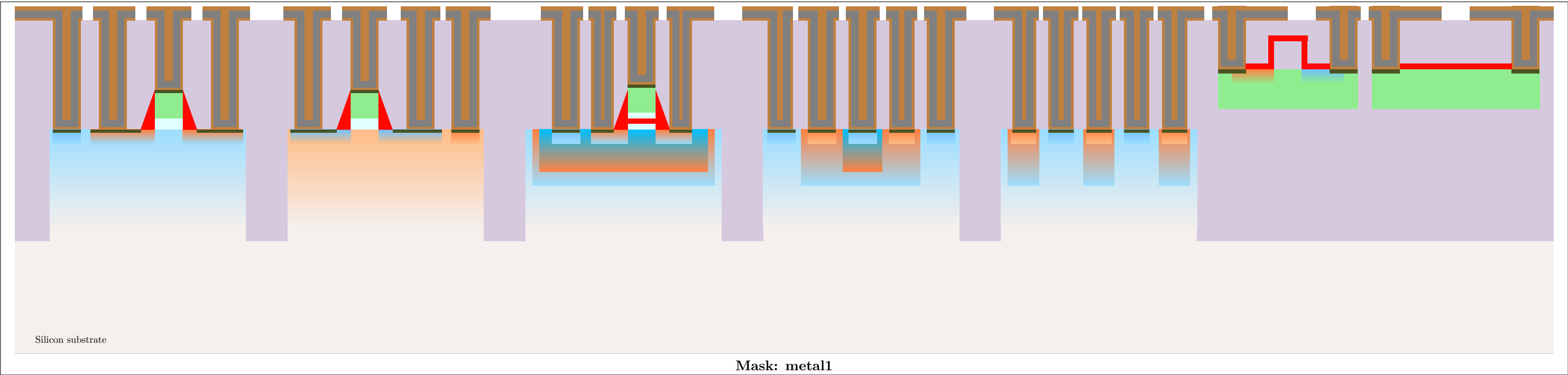
| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|--|----------|------------------|-----------------------------|--|
| Clean | 13.1 | A3:Sulfuric cleaning (WET-A3) | P2-01000 | Clean | Default cleaning | |
| Clean | 13.2 | Spin Dryer-A (SRD-A) | P2-01000 | Clean | Dry the wafer automatically | |
| Clean | 13.3 | LPCVD-B2 Nitride/Low-Stress Nitride (CVD-B2) | P2-01000 | Clean | Spacer nitride | 50 nm |
| 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 |
| Clean | 13.5 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Clean | 13.6 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Clean | 13.7 | NFF RIE Etcher (DRY-RIE-2) | P2-01000 | Clean Semi clean | Anisotropic nitride etch | 120 seconds |
| Clean | 13.8 | E4:Resist strip (WET-E4) | P2-01000 | Clean Semi clean | Sulfuric resist strip | H2SO4+H2O2, 120°C , 10mins |
| Clean | 13.9 | Spin Dryer-E (SRD-E) | P2-01000 | Clean Semi clean | Dry the wafer automatically | |
| Semi clean | 13.10 | NSC3000 Sputter (SPT-NSC3000) | P2-01000 | Semi clean | Deposit Titanium | 50nm |

14 Contact

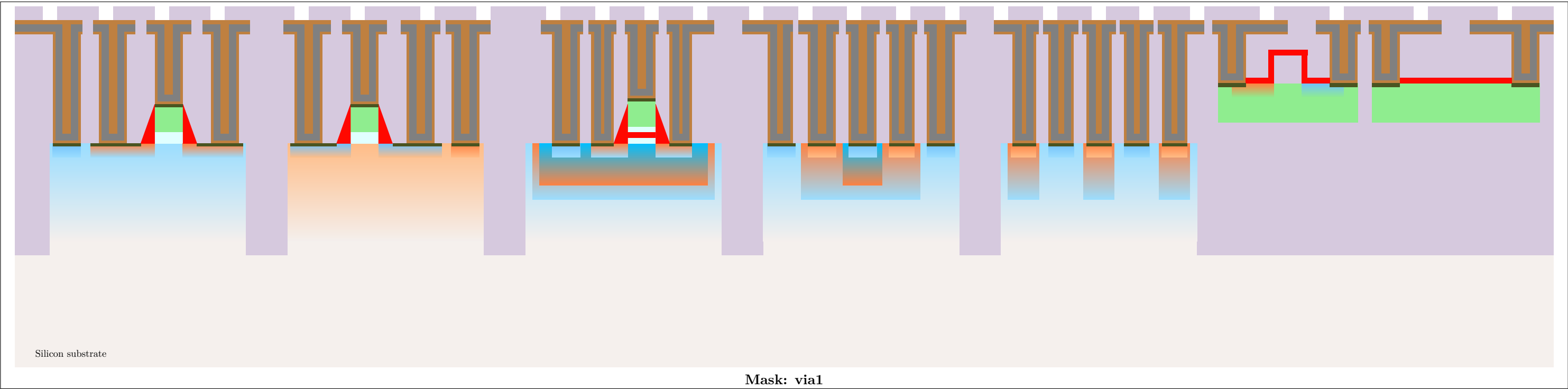


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean | 14.1 | D1: Dump rinse (WET-D-DR) | P2-01000 | Semi clean | Wafer cleaning | |
| Semi clean | 14.2 | LPCVD-F4 LTO/PSG (CVD-F4) | P2-01000 | Semi clean | Oxide deposition | 150 nm |
| Semi clean | 14.3 | 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 |
| Semi clean | 14.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Semi clean | 14.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Semi clean | 14.6 | NFF RIE Etcher (DRY-RIE-2) | P2-01000 | Clean Semi clean | 150nm LTO etch | 3 minutes |
| Semi clean | 14.7 | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean | Resist strip | 10mins |
| Semi clean | 14.8 | Spin Dryer-Y (SRD-Y) | P2-00100 | Semi clean | Spin dry | |

15 Metal 1

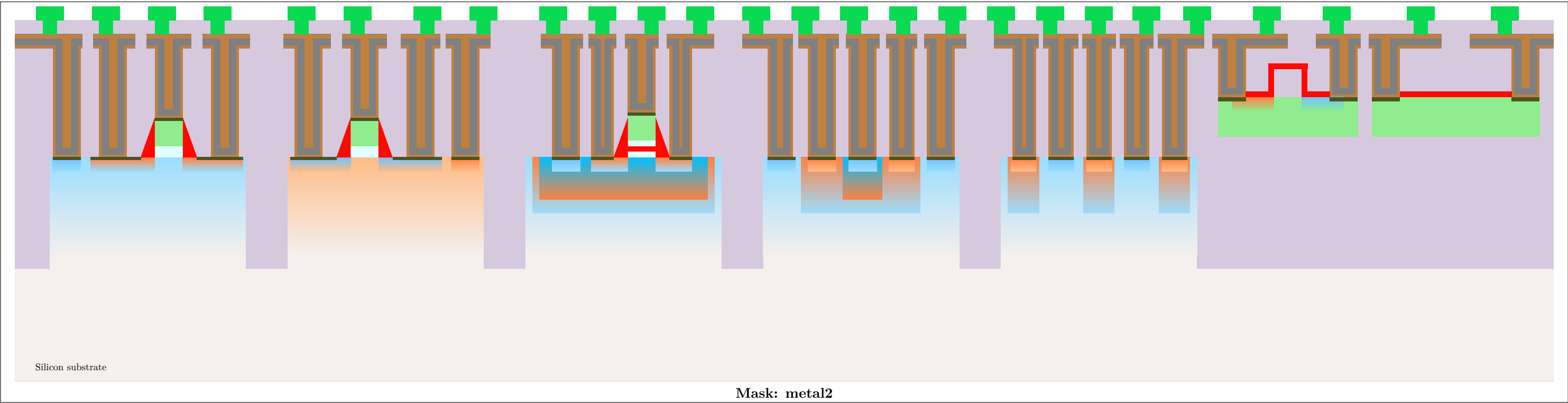


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---------------------------------|----------|------------------|---|--|
| Semi clean | 15.1 | NSC3000 Sputter (SPT-NSC3000) | P2-01000 | Semi clean | Nickel diffusion barrier + Deposit Aluminum + Nickel finish | Nickel (roughly 50nm) + Aluminum (roughly 100nm) + Nickel (roughly 50nm) |
| Semi clean | 15.2 | 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 | 15.3 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Semi clean | 15.4 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Semi clean | 15.5 | AST Metal Etcher (DRY-Metal-1) | P2-01000 | Semi clean | Wire formation | 200 nm |
| Semi clean | 15.6 | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean | Resist strip | 10mins |
| Semi clean | 15.7 | Spin Dryer-Y (SRD-Y) | P2-00100 | Semi clean | Spin dry | |

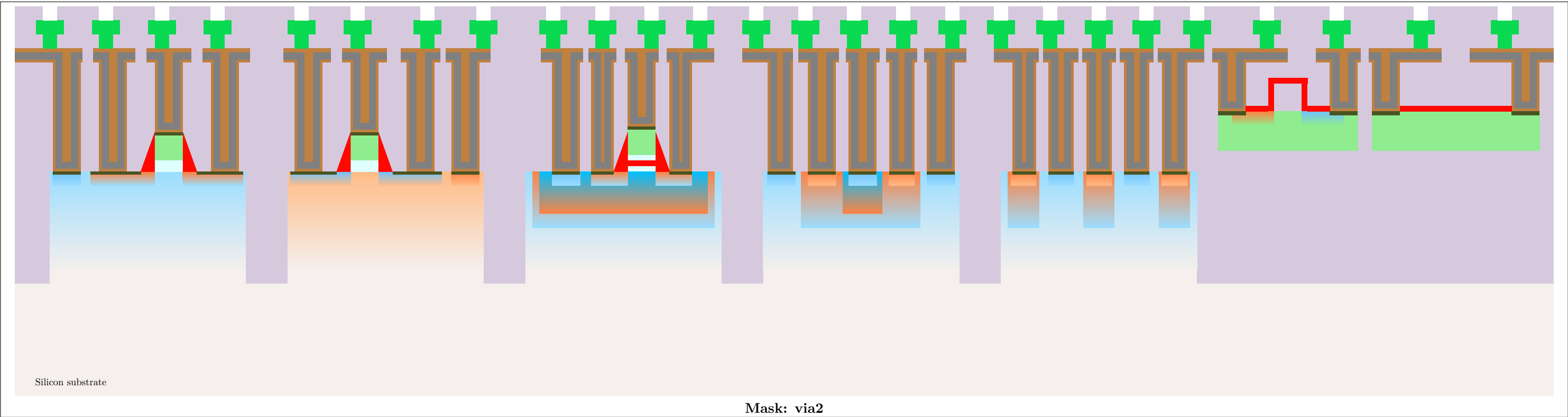


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean | 16.1 | D1: Dump rinse (WET-D-DR) | P2-01000 | Semi clean | Wafer cleaning | |
| Semi clean | 16.2 | LPCVD-F4 LTO/PSG (CVD-F4) | P2-01000 | Semi clean | Oxide deposition | 150 nm |
| Semi clean | 16.3 | 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 |
| Semi clean | 16.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Semi clean | 16.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Semi clean | 16.6 | NFF RIE Etcher (DRY-RIE-2) | P2-01000 | Clean Semi clean | 150nm LTO etch | 3 minutes |
| Semi clean | 16.7 | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean | Resist strip | 10mins |
| Semi clean | 16.8 | Spin Dryer-Y (SRD-Y) | P2-00100 | Semi clean | Spin dry | |

17 Metal 2

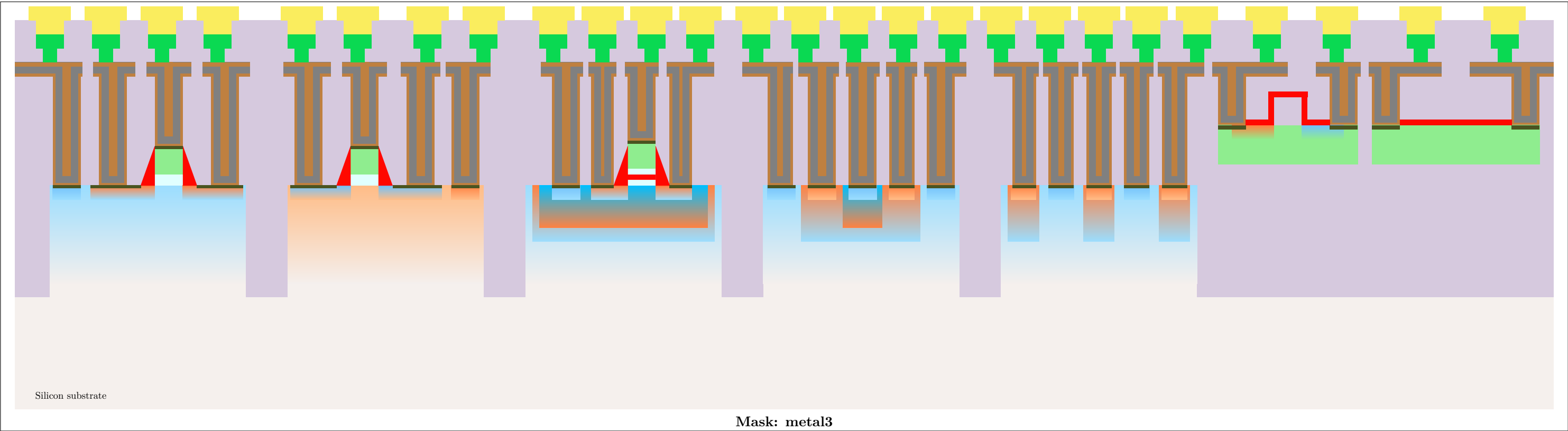


| Mask: metal2 | | | | | | |
|-------------------|-------------|---------------------------------|----------|------------------|----------------------------------|--|
| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
| Semi clean | 17.1 | NSC3000 Sputter (SPT-NSC3000) | P2-01000 | Semi clean | Deposit Aluminum + Nickel finish | Aluminum (roughly 100nm) + Nickel (roughly 50nm) |
| Semi clean | 17.2 | 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 | 17.3 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Semi clean | 17.4 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Semi clean | 17.5 | AST Metal Etcher (DRY-Metal-1) | P2-01000 | Semi clean | Wire formation | 150 nm |
| Semi clean | 17.6 | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean | Resist strip | 10mins |
| Semi clean | 17.7 | Spin Dryer-Y (SRD-Y) | P2-00100 | Semi clean | Spin dry | |

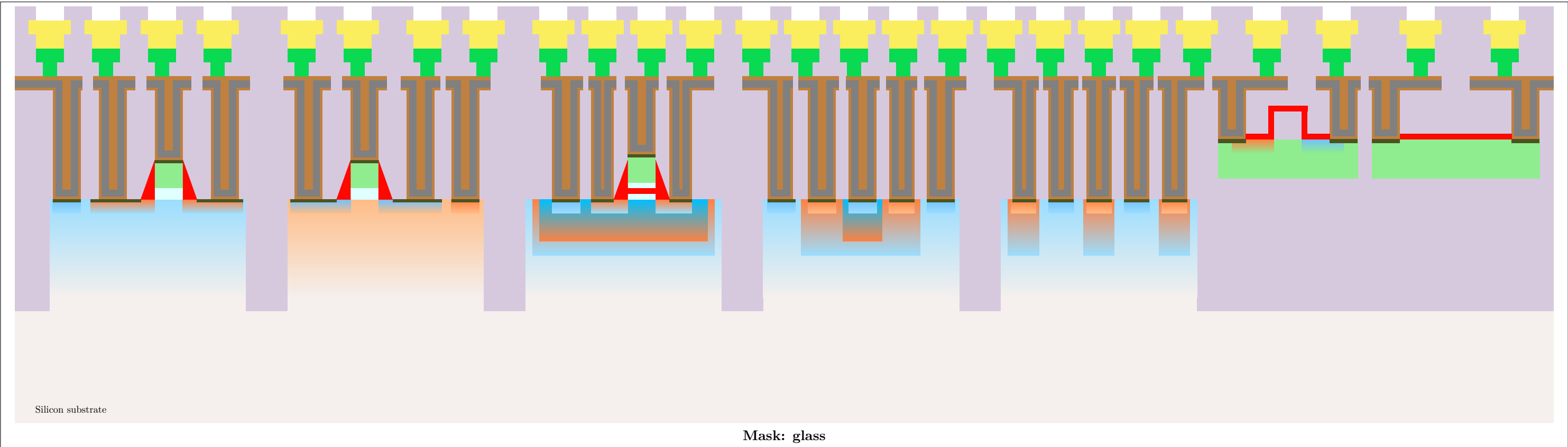


| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean | 18.1 | D1: Dump rinse (WET-D-DR) | P2-01000 | Semi clean | Wafer cleaning | |
| Semi clean | 18.2 | LPCVD-F4 LTO/PSG (CVD-F4) | P2-01000 | Semi clean | Oxide deposition | 150nm |
| Semi clean | 18.3 | 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 |
| Semi clean | 18.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Semi clean | 18.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Semi clean | 18.6 | NFF RIE Etcher (DRY-RIE-2) | P2-01000 | Clean Semi clean | 150nm LTO etch | 3 minutes |
| Semi clean | 18.7 | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean | Resist strip | 10mins |
| Semi clean | 18.8 | Spin Dryer-Y (SRD-Y) | P2-00100 | Semi clean | Spin dry | |

19 Metal 3



| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---------------------------------|----------|------------------|----------------------------------|--|
| Semi clean | 19.1 | NSC3000 Sputter (SPT-NSC3000) | P2-01000 | Semi clean | Deposit Aluminum + Nickel finish | Aluminum (roughly 100nm) + Nickel (roughly 50nm) |
| Semi clean | 19.2 | 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 | 19.3 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Semi clean | 19.4 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Semi clean | 19.5 | AST Metal Etcher (DRY-Metal-1) | P2-01000 | Semi clean | Wire formation | 150 nm |
| Semi clean | 19.6 | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean | Resist strip | 10mins |
| Semi clean | 19.7 | Spin Dryer-Y (SRD-Y) | P2-00100 | Semi clean | Spin dry | |



| Wafer Cleanliness | Step Number | Equipment | Location | Cleanliness | Process | Requirements |
|-------------------|-------------|---------------------------------|----------|------------------|-----------------------------|--|
| Semi clean | 20.1 | D1: Dump rinse (WET-D-DR) | P2-01000 | Semi clean | Wafer cleaning | |
| Semi clean | 20.2 | LPCVD-F4 LTO/PSG (CVD-F4) | P2-01000 | Semi clean | Oxide deposition | 150nm |
| Semi clean | 20.3 | 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 |
| Semi clean | 20.4 | ASML Stepper (PHT-S1) | P2-00100 | Clean Semi clean | Exposure of the layer | $280mJcm^2$ |
| Semi clean | 20.5 | SVG Developer Track (PHT-T2) | P2-00100 | Clean Semi clean | Develop, Hard bake | FHD-5, 1min; hard bake: 120°C , 1min |
| Semi clean | 20.6 | NFF RIE Etcher (DRY-RIE-2) | P2-01000 | Clean Semi clean | 150nm LTO etch | 3 minutes |
| Semi clean | 20.7 | Y1:MS2001 Resist strip (WET-Y1) | P2-00100 | Semi clean | Resist strip | 10mins |
| Semi clean | 20.8 | Spin Dryer-Y (SRD-Y) | P2-00100 | Semi clean | Spin dry | |

