EPSRC
Engineering and Physical Sciences Research Council

CORNERSTONE

Design guidelines for the eleventh fabrication call – December 2018

Notification of intention to submit deadline – Friday 18th January 2019

Mask submission deadline – Friday 1st March 2019

File format = *.gdsII*.

Manufacturing grid size = 1 nm.

Design area = **11.47 x 4.9 mm²**, with 0.5 mm bleed regions on the east and west facets if desired.

Top cell name: 'Cell0_*[Name of Institution]*'.

1. Major changes to design submission process

For this call there are major changes to the design submission process (see Section 7 of CORNERSTONE 11th Call - Design Rules.pdf) to align with the introduction of the CORNERSTONE terms and conditions, which are available to download from the CORNERSTONE website:

www.cornerstone.sotonfab.co.uk/terms-and-conditions

All design submissions, even those that are supported by EPSRC funding, must agree with the terms and conditions. Under no circumstances will we accept designs without agreement with the terms.

Therefore, we strongly recommend that the terms and conditions are pre-authorised by your institution prior to the mask submission date.

Section 7 of the CORNERSTONE 11th Call - Design Rules.pdf document details the new design submission process in detail.

Note that the modulator designs included in the IPKISS PDK and *.gdsII* template are protected under several patents: US9343638B2, US9684194B2, US9547187B2, US8958678B2, GB2490850, GB2493690, GB2544249.

2. Design rule changes from previous active device design rules (MPW #4)

The following is a list of design rule changes from the previous active device design rules:

1. Process design kit (PDK) using Luceda's IPKISS software implemented (Section 3 of CORNERSTONE 11th Call - Design Rules.pdf).
2. Minimum feature size for grating coupler layer (GDS layer 6) reduced to 200 nm. Minimum gap set as 250 nm for features up to 20 µm long, and 300 nm for features longer than 20 µm.
3. Minimum feature size for the waveguide layer (GDS layer 3) increased to 350 nm. Minimum gap reduced to 200 nm.
4. Minimum feature size, and gap, of all implant layers increased to 500 nm.
5. New 'labels' layer added as GDS layer 100. This layer will not have any design rule checking (DRC) performed on it and will be merged with Silicon Etch 2 by the CORNERSTONE team.
6. Target critical dimensions for each GDS layer added (Table 1).
7. Heaters must now be formed in the electrode layer (GDS layer 13).
8. Step-by-step details of the mask processing steps carried out by the CORNERSTONE team added (Section 8 of CORNERSTONE 11th Call - Design Rules.pdf).

9. Standard single mode waveguide width for λ = 1.55 µm increased to 450 nm.
10. 1x2 rib MMI length for λ = 1.55 µm increased to 32.7 µm.
11. Grating coupler design for λ = 1.31 µm modified.

3. Design rules summary

A summary of the design rules and GDS layer numbers can be found in Table 1 below.

Table 1 – Design rules summary.

Layer description	GDS number	Field	Min. feature size	Min. gap	Max. feature width	Target critical dimension
Silicon Etch 1 (70 nm ± 10 nm)	6	Dark	200 nm	250 nm	20 µm	315 nm
			200 nm	300 nm	N/a	
Silicon Etch 2 (120 nm ± 10 nm)	3	Light	350 nm	200 nm	N/a	450 nm
	4	Dark	200 nm	350 nm		
Silicon Etch 3 (100 nm to BOX)	5	Light	250 nm	250 nm	N/a	250 nm
Low Dose *p*-type Implant	7	Dark	500 nm	500 nm	40 µm	500 nm
Low Dose *n*-type Implant*	8	Dark	500 nm	500 nm	10 µm	500 nm
High Dose *p*-type Implant	9	Dark	500 nm	500 nm	10 µm	500 nm
High Dose *n*-type Implant	11	Dark	500 nm	500 nm	10 µm	500 nm
Vias (rounded feature corners)	12	Dark	3 µm	5 µm	10 µm	3 µm
Electrodes	13	Light	6 µm	4 µm	N/a	4 µm
Bleed Area	98	N/a	N/a	N/a	N/a	N/a
Cell Outline	99	N/a	N/a	N/a	N/a	N/a
Labels**	100	Dark	250 nm	250 nm	N/a	N/a

*Angled implant from the south direction.
**Features drawn in the Labels layer will be merged into Silicon Etch 2 by the CORNERSTONE team.

4. Minimum feature sizes, tolerances and other design rules

- Minimum feature sizes, minimum gaps, and maximum feature widths for each GDS layer are detailed in Table 1.
- The target critical dimension for each GDS layer is listed in Table 1. Note that other feature sizes may have a small dimension bias.
- A minimum spacing between waveguides of at least 5 µm is recommended to avoid power coupling.
- An overlap of at least 200 nm between GDS layers is essential to account for the alignment tolerance between layers.
- All structures drawn in GDS layer 6 (Grating couplers) must overlap by at least 200 nm with GDS layer 3 (Waveguides).
- All structures drawn in GDS layer 5 (Rib protect) should extend 10 µm beyond the edge of GDS layer 3 (Waveguides), with the exception of rib-to-strip transitions.
- All structures drawn in GDS layer 9 and GDS layer 11 (high dose implant layers) should not overlap with GDS layer 3 (Waveguides). The high dose implants will be masked by the hard mask regardless.
- All structures drawn in GDS layer 12 (Vias) must have the corners rounded with a minimum bend radius of 1 µm (recommended bend radius = 2.5 µm).

- All structures drawn in GDS layer 12 (Vias) must be inclusive of either GDS layer 9 (High Dose *p*-type Implant) or GDS layer 11 (High Dose *n*-type Implant) by at least 500 nm (i.e. the high dose implant layer must extend in all directions at least 500 nm beyond the vias layer).
- All structures drawn in GDS layer 12 (Vias) must be inclusive of the metal contacts drawn in GDS layer 13 (Electrodes) by at least 500 nm (i.e. the electrode layer must extend in all directions at least 500 nm beyond the vias layer).
- Ensure all structures drawn in GDS layer 6 (Grating couplers) do not overlap with either GDS layer 12 (Vias) or GDS 13 (Electrodes).

5. Process parameters overview

A cross-section of a carrier depletion modulator structure is shown in Figure 1, along with the important device parameters, including doping concentrations, listed in Table 2.

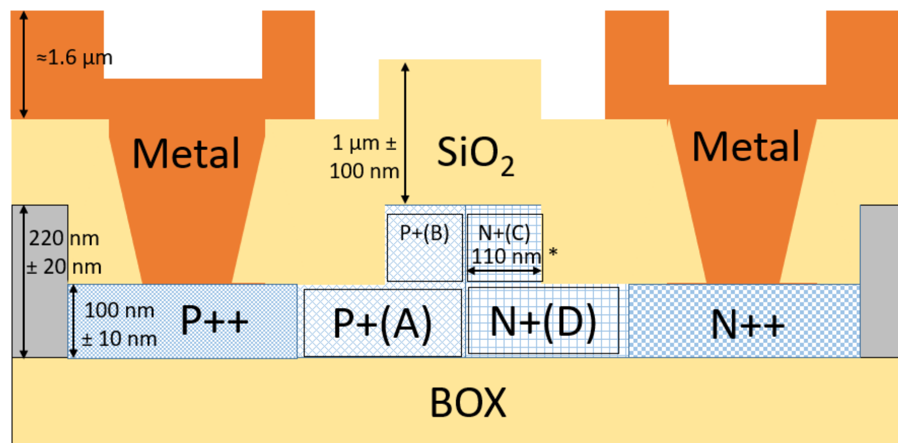

*Figure 1 – Process parameters overview. *The N+ implant is performed at 45°, so the implanted region is fixed at 110 nm from waveguide edge (controlled by the angled implant energy).*

Table 2 – Important device parameters.

Property	Specification
Si overlayer thickness	220 nm ± 20 nm
Grating etch depth	70 nm ± 10 nm
Rib waveguide etch depth	120 nm ± 10 nm
P+ region (A)	≈ 3.8E17 cm^{-3}
P+ region (B)	≈ 1.5E17 cm^{-3}
N+ region (C)*	≈ 7.5E17 cm^{-3}
N+ region (D)*	≈ 1.1E18 cm^{-3}
P++	≈ 1E20 cm^{-3}
N++	≈ 1E20 cm^{-3}
Top cladding SiO_2 thickness	1 µm ± 100 nm
Metal thickness	≈ 1.6 µm

**Note:* The low dose *n*-type implant concentrations are compensated by the background low dose *p*-type implant (i.e. the low dose *n*-type region must fully overlap with the low dose p-type region; otherwise, the actual *n*-type concentrations will be higher than specified).

6. Technical support

For all queries, email cornerstone@soton.ac.uk.