TU/e extension PDK for SMART Photonics HS28PC

Introduction

The TU/e extension PDK (`tue4smart`) currently contains the building blocks that are listed below with a brief description. These building blocks are fully described in the corresponding uPDK file[1]. They can be implemented and used with all compliant software. Use is free of charge for non-commercial use, which is when these building blocks are used within multi-project wafer runs. Use of this PDK outside regular multi-project runs may require a separate license from TU Eindhoven.

Building block maturity level

For most of the building blocks a "building block maturity" level is specified. This is not an exact classification, but it should give the user some idea of the confidence to put in a certain building block. The following levels are specified:

Description (guideline)	Slider
Building block was simulated and designed and is expected to be functional	[o----]
Building block was tested in a trial run and was shown to be functional	[-o---]
Building block was tested in multiple runs and was shown to be functional	[--o--]
Building block was tested in multiple runs and some characterization data is available/published	[---o-]
Building block was tested in multiple runs and full characterization data is available/published	[----o]

Building blocks

mmi1x2_sh

1x2 MMI coupler with equal (50%/50%) splitting ratio. The input/output waveguides are shallow etched with standard (2.0 µm) width.

Building block maturity: low [---o-] high

[1] See `https://openEPDA.org/updk/pdk_components.html` for more information about the uPDK format.

mmi2x2_sh

2x2 MMI coupler with equal (50%/50%) splitting ratio. The input/output waveguides are shallow etched with non-standard (3.5 µm) width. The user needs to add proper tapers. A parabolic taper of 50 µm length should provide a low-loss connection to the standard 2 µm wide waveguide.

Building block maturity: low [---o-] high

lrmmi1x2_dp

Low-reflection 1x2 MMI splitter. The input/output waveguides are deep etched with standard (1.5 µm) width. This splitter is modeled after this publication: E. Kleijn, D. Melati, A. Melloni, T. de Vries, M.K. Smit, and X.J.M. Leijtens. "Multimode interference couplers with reduced parasitic reflections". IEEE Photon. Technol. Lett., 26(4):408-410, February 2014 `http://ieeexplore.ieee.org/abstract/document/6690121`.

Building block maturity: low [-o---] high

mmi8515_sh

2x2 MMI coupler with unequal splitting ratio: 85%/15%. The cross port has 85% transmission, the bar port has 15% transmission. The input/output waveguides are shallow etched with standard (2.0 µm) width.

This component is based on the theory described in M. Bachmann, P. Besse, and H. Melchior, "Overlapping-image multimode interference couplers with a reduced number of self-images for uniform and nonuniform power splitting," Appl. Opt., vol. 34, pp. 6898-6910, Oct. 1995 `http://www.osapublishing.org/ao/abstract.cfm?uri=ao-34-30-6898`.

Building block maturity: low [--o--] high

mmi8515_dp

2x2 MMI coupler with unequal splitting ratio: 85%/15%. The cross port has 85% transmission, the bar port has 15% transmission. The input/output waveguides are deep etched with non-standard (2.0 µm) width. The user needs to add proper tapers. A parabolic taper of 16 µm length should provide a low-loss connection to the standard 1.5 µm width.

This component is based on the theory described in M. Bachmann, P. Besse, and H. Melchior, "Overlapping-image multimode interference couplers with a reduced number of self-images for uniform and nonuniform power splitting," Appl. Opt., vol. 34, pp. 6898-6910, Oct. 1995 `http://www.osapublishing.org/ao/abstract.cfm?uri=ao-34-30-6898`.

Building block maturity: low [--o--] high

mmi7228_sh

2x2 MMI coupler with unequal splitting ratio: 72%/28%. The cross port has 72% transmission, the bar port has 28% transmission. The input/output waveguides are shallow etched with standard

(2.0 µm) width.

This component is based on the theory described in M. Bachmann, P. Besse, and H. Melchior, "Overlapping-image multimode interference couplers with a reduced number of self-images for uniform and nonuniform power splitting," Appl. Opt., vol. 34, pp. 6898-6910, Oct. 1995 http://www.osapublishing.org/ao/abstract.cfm?uri=ao-34-30-6898.

Building block maturity: low [--o--] high

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Building block maturity: low [--o--] high

mir2p_pi_sh

2 port MIR reflector with pi phase shift between the reflected signals. The input/output waveguides are shallow etched with standard (2.0 µm) width.

This component is based on the work presented in D. D'Agostino, D. Lenstra, H. Ambrosius, and M. Smit, "Widely tunable multimode-interference based coupled cavity laser with integrated interferometer," Optics Express, vol. 26, pp. 14159-14173, May 2018 http://www.osapublishing.org/oe/abstract.cfm?uri=oe-26-11-14159.

Building block maturity: low [-o---] high

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Building block maturity: low [-o---] high

ring_laser_amzi_dp

Sylwester's ring laser with asymmetric Mach-Zehnder filters. This is an implementation the original Ring AMZI laser by Sylwester Latkowski. This laser is for use on semi-insulating (SI) substrates. It includes the following features:

- 3 stage AMZI based tunable wavelength selective filter
- 2x2MMI outcoupler with MIR at one output
- In-line phase shifter (ERM) for cavity modes tuning (not in the paper)

Information about the laser is published in S. Latkowski, A. Hänsel, N. Bhattacharya, T. de Vries, L. Augustin, K. Williams, M. Smit, and E. Bente, "Novel widely tunable monolithically integrated laser source," IEEE Photonics Journal, vol. 7, pp. 1-9, Dec 2015 http://doi.org/10.1109/JPHOT.2015.2493722.

Building block maturity: low [o----] high

basic_dbr_laser_phase_sh

DBR laser containing a front and rear DBR grating, a gain section, a phase section and a monitor photodiode. The laser building block is based on the work of Dan Zhao, as published in §5.2 of her thesis "High-precision distributed Bragg reflectors in a generic photonic integration platform", ISBN 978-90-386-4627-5 https://research.tue.nl/files/109390782/20181113_Zhao.pdf. This version has no prope pads connected to the laser.

Building block maturity: low [--o--] high

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Building block maturity: low [--o--] high

awg_sh

Arrayed waveguide grating (AWG) building block with shallow etched input and output waveguides. Design is following the description in: M. Smit and C. van Dam, "PHASAR-based WDM-devices: principles, design and applications," IEEE J. Sel. Topics in Quantum Electron., vol. 2, pp. 236-250, June 1996 https://ieeexplore.ieee.org/document/577370.

Due to design parameter uncertainty and process variations, the center wavelength can easily vary by a few nm from run to run. The difference between the center wavelength of two AWGs with an identical design in the same design cell will be much smaller.

Building block maturity: low [-o---] high

awg_dp

Arrayed waveguide grating (AWG) building block with deeply etched input and output waveguides. Design is following the description in: M. Smit and C. van Dam, "PHASAR-based WDM-devices: principles, design and applications," IEEE J. Sel. Topics in Quantum Electron., vol. 2, pp. 236-250, June 1996 https://ieeexplore.ieee.org/document/577370.

Due to design parameter uncertainty and process variations, the center wavelength can easily vary by a few nm from run to run. The difference between the center wavelength of two AWGs in the same design cell will be much smaller.

Building block maturity: low [-o---] high

Licensing

The building blocks provided by the tue4smart extension PDK can be used free of charge for non-commercial use (i.e. in multi-project wafer runs). Should a (scientific) publication result from devices or circuits that make use of one or more of these building blocks, then the Eindhoven University of Technology should be acknowledged for it in the publication.

Commercial use of the tue4smart building blocks (i.e. outside regular multi-project wafer runs) is possible, but may require a license. For more information, please contact X.J.M.Leijtens@tue.nl.

Disclaimer

The building blocks offered by this extension PDK are provided "as is" and fitness for a particular purpose is disclaimed. In no event shall TU/e or contributors be liable for any damages resulting from the use of these building blocks.