Closed-loop Modeling of Silicon Nanophotonics: From Design to Fabrication and Back Again

(invited paper)

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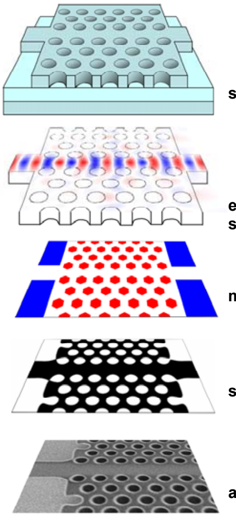
We present a system for closed-loop modeling of silicon nanophotonics, where the properties of the fabrication process are taken into account in the design and optimization of nanophotonic components.

Summary



When fabricating nanophotonic components, several aspects come into play. There is the detailed electromagnetic simulation of the component, the generation of the mask layout, and the properties of the fabrication process which make that the fabricated structure is often not exactly identical to the one that was originally designed. We present a framework where all of these aspects are integrated in such a way that the properties of the fabrication can be taken into account during the design phase.

The framework is held together with Python, a flexible programming language especially suitable for scientific applications [1]. Currently, the framework has a python interface to an electromagnetic simulator based on eigenmode expansion [2], a library for mask layout design, and a simulator for optical projection lithography. This last library is calibrated against actual fabrication processes using the 248nm and 193nm steppers used by IMEC for the fabrication of nanophotonic waveguide circuits [3].

In addition, python makes it exceptionally easy to include new interfaces to existing software tools (commercial and free), including advanced optimization routines such as genetic algorithms.

To demonstrate this framework we optimize an in-line DBR reflector in a photonic wire. A design with rectangular grating teeth will be deformed by the optical lithography, because for submicron features the lithography acts as a spatial low-pass filter, rounding sharp corners. Therefore, while an optimization routine on the rectangular design might yield an efficient component, the actual fabricated structure would be very different. Thus, we included the lithography in the optimization loop. Starting from a mask design, we perform a virtual lithography, and the resulting pattern is fed to CAMFR. The result is used to modify the mask layout, taking into account design rules such as minimal spacing. This whole cycle is then managed by an optimization routine, in this case a relatively simple steepest descent method.

References

[1] Special issue on Python of *Computing in Science & Engineering*, vol. 9(3) (2007)
[2] P. Bienstman and R. Baets, *Opt. Quantum. Electron* 33(4/5), p.327 (2001)
[3] W. Bogaerts et al. *J. Lightwave Technol.* 23(1), p.401 (2005)

Eindhoven, The Netherlands, June 11-13, 2008

Proceedings
14th European Conference on Integrated Optics

Contributed and Invited Papers

ECIO 08
EINDHOVEN

June 11–13, 2008
Eindhoven University of Technology
The Netherlands

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COBRA Institute
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Editor
X.J.M. Leijtens