

## Photon control by multi-periodic binary grating waveguides: A coupled-mode theory approach

Adam, Jost; Lüder, Hannes; Gerken, Martina

*Publication date:*  
2015

*Document version*  
Submitted manuscript

*Citation for published version (APA):*  
Adam, J., Lüder, H., & Gerken, M. (2015). *Photon control by multi-periodic binary grating waveguides: A coupled-mode theory approach*. Abstract from Optical wave and waveguide theory and numerical modelling workshop, London, United Kingdom.

### Terms of use

This work is brought to you by the University of Southern Denmark through the SDU Research Portal. Unless otherwise specified it has been shared according to the terms for self-archiving. If no other license is stated, these terms apply:

- You may download this work for personal use only.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying this open access version

If you believe that this document breaches copyright please contact us providing details and we will investigate your claim. Please direct all enquiries to [puresupport@bib.sdu.dk](mailto:puresupport@bib.sdu.dk)

# Photon control by multi-periodic binary grating waveguides: A coupled-mode theory approach

J. Adam<sup>1</sup>, H. Lüder<sup>2</sup>, M. Gerken<sup>2</sup>

<sup>1</sup> Mads Clausen Institute, University of Southern Denmark, Alsion 2, DK-6400 Sønderborg, Denmark

<sup>2</sup> Institute of Electrical and Information Engineering, Christian-Albrechts-Universität zu Kiel, Kaiserstr. 2, D-24143 Kiel, Germany  
[jostadam@mci.sdu.dk](mailto:jostadam@mci.sdu.dk)

We present a coupled-mode theory (CMT) approach for the description of the modal behavior of planar waveguides with binary corrugations, created by the superposition of multiple binary gratings with varying pitches and fill factors. We present inter-modal coupling results for both, bound and radiating states.

## Summary

In order to control the photon emission from thin-film devices, high-index layer structuring is frequently used to increase guided light outcoupling efficiency. Multi-periodic nanostructures, yielded by a logical disjunction of multiple binary gratings, have recently been proposed to achieve simultaneous control over multiple spectral resonance positions and relative intensities [1]. The experimental findings were theoretically backed up by a rigorous coupled-wave analysis (RCWA, [2]) approach, yielding the leaky modes' complex propagation constants and diffraction efficiencies. This approach, however, can only lead to quantitative results outside the device's band gaps, since only radiative propagation loss is calculated. In order to provide more physical and quantitative insight to grating-induced waveguide losses, we implemented a coupled-mode theory (CMT, [3]) approach for the semi-analytical treatment of the corrugated waveguides modal behavior. In this contribution, we present guided-to-guided as well as guided-to-radiation mode coupling in multi-periodic binary grating waveguides.

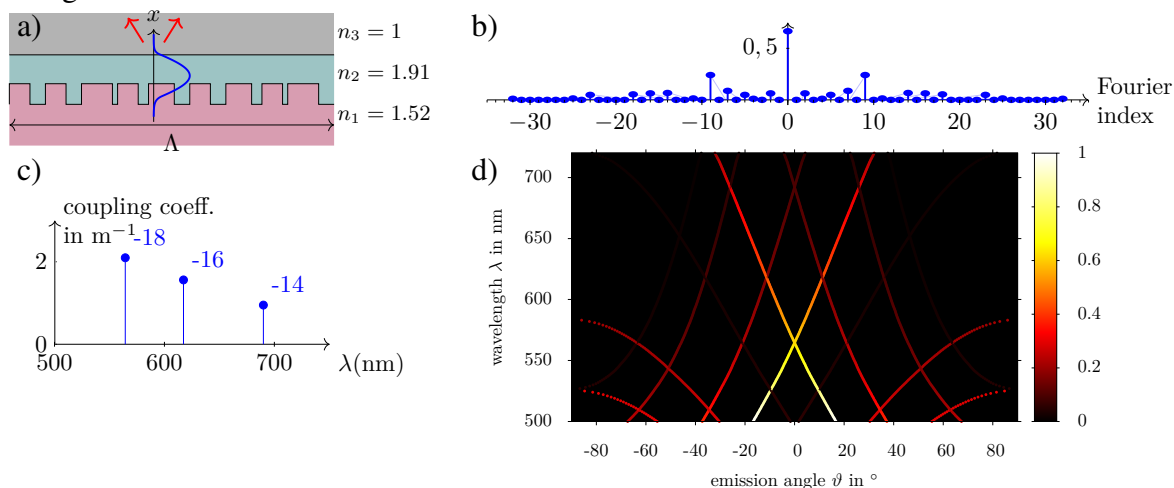


Figure 1: Transverse-electric (TE) modal behaviour of a two-periodic waveguide, with periods 350 nm and 450 nm; a) geometry sketch and  $TE_0$  mode profile, b) Fourier index moduli for the two-periodic grating, c)  $TE_0$  to  $TE_{-0}$  mode-coupling coefficients, d) normalized  $TE_0$  to radiation-mode coupling coefficients.

The authors gratefully acknowledge financial support by the European Research Council, grant number 307800.

## References

- [1] K. Kluge, J. Adam, N. Barie, P.-J. Jakobs, M. Guttman, M. Gerken, *Opt. Express* **22**(S5):A1363 (2014).
- [2] M. Moharam, E. Grann, D. Pommet, and T. Gaylord, *J. Opt. Soc. Am. A*, **12**(5):1068 (1995).
- [3] S. M. Norton, T. Erdogan, and G. M. Morris, *J. Opt. Soc. Am. A*, **14**(3):629 (1997).