



Designing Manufacturable Photonic and Plasmonic Structures using Topology Optimization

Christiansen, Rasmus Ellebæk; Sigmund, Ole

Publication date:
2019

Document Version
Peer reviewed version

[Link back to DTU Orbit](#)

Citation (APA):

Christiansen, R. E., & Sigmund, O. (2019). *Designing Manufacturable Photonic and Plasmonic Structures using Topology Optimization*. Abstract from 2019 IEEE MTT-S International Conference on Numerical Electromagnetic and Multiphysics Modeling and Optimization (NEMO2019), Cambridge, United States.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- 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 the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Designing Manufacturable Photonic and Plasmonic Structures using Topology Optimization

Authors: *Rasmus Ellebæk Christiansen*¹, *Ole Sigmund*.

Department of Mechanical Engineering, Technical University of Denmark.

Since the first application of density based topology optimization to photonic-crystal structure synthesis [1], the field has experienced a tremendous development. During the 2000s the use of topology optimization in photonic design expanded to include photonic-crystal band-gap engineering, design of slow-light wave-guides, photonic filters and modulators as well as plasmonic grating couplers [2]. This was followed in the 2010s by applications to the design of multiplexers and power-splitters, hyperlenses and on-chip Fabry-Pérot resonators [3] to name a few examples. Further developments, refinement and applications to ever more complex design problems are ongoing.

A key reason for the growing interest in topology optimization as a design tool is the ultimate geometric design freedom provided by the method, the only restriction being the resolution of the design field, which in principle can be made arbitrarily fine. This design freedom, however, comes with a crucial pitfall in the form of the lack of any inherent detail- or length-scale control in the design process if no special measures are taken. Lack of a strict feature size control risks rendering the physics modelling inaccurate, makes designs highly sensitive to manufacturing uncertainties and/or hinders accurate fabrication by standard processes.

The talk will provide a review of selected advanced geometric control methods which establish detail- and length-scale control as well as robustness [4] in the topology optimization process, hereby ensuring accurate modelling of the physics, manufacturability and guarantee agreement between numerical predictions and practical measurements.

Finally, some recent applications of density based topology optimization to the design of photonic resonators [5], plasmonic field enhancement devices [6], photonic up-conversion structures [7] and topological insulators, will be presented and discussed.

References

- [1] P. I. Borel, A. Harpoth, L. H. Frandsen, M. Kristensen, P. Shi, J. S. Jensen and O. Sigmund, *Topology optimization and fabrication of photonic crystal structures*. Optics Express 12(9), 1996-2001, (2004).
- [2] J. S. Jensen and O. Sigmund, *Topology optimization for nano-photonics*. Laser & Photonics Reviews 5(2), 306-321, (2011).
- [3] S. Molesky, Z. Lin, A. Y. Piggott, W. Jin, J. Vuckovic and A. W. Rodriguez, *Inverse design in nanophotonics*. Nature Photonics 12, 659-670, (2018).
- [4] F. Wang, B. S. Lazarov and O. Sigmund. *On projection methods, convergence and robust formulations in topology optimization*. Structural and Multidisciplinary Optimization 43(6), 767-784, (2011).
- [5] F. Wang, R. E. Christiansen, Y. Yu, J. Mørk and O. Sigmund. *Maximizing the quality factor to volume ratio for ultra-small photonic crystal cavities*. arXiv:1810.02417v1, (2018).
- [6] R. E. Christiansen, J. Vester-Petersen, S. P. Madsen and O. Sigmund *A non-linear material interpolation for design of metallic nano-particles using topology optimization*. Computer Methods in Applied Mechanics and Engineering 343, 23-39, (2019).
- [7] J. Vester-Petersen, R. E. Christiansen, B. Julsgaard, P. Balling, O. Sigmund and S. P. Madsen *Topology optimized gold nanostrips for enhanced near-infrared photon upconversion*. Applied Physics Letters 111, 133102, (2017).

¹E-mail: raelch@mek.dtu.dk

Address: Nils Koppels Allé 404, DK-2800 Kgs. Lyngby, Denmark