

BROADBAND OPTIMIZATION AND ROBUSTNESS TO GEOMETRIC IMPERFECTIONS OF NANOPHOTONIC DESIGNS

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Abstract

Topology optimization (TopOpt) in nanophotonics engineering promises next-generation optical devices with unprecedented performance and functionalities. Compared with conventional design approaches, TopOpt enables superior designs by exploiting a large number of degrees of freedom and precise control of light at the nanoscale. However, if no countermeasures are taken, the optimized response is often highly sensitive to small geometrical variations, which naturally result from manufacturing imperfections in lithographic fabrication processes. It is therefore a major focus of current research to explore optimization schemes that account for those uncertainties and enable optical designs that are robust against geometrical imperfections encountered in practice. Stochastic methods belong to the most promising approaches for addressing this challenge. These typically rely on sample-based stochastic formulations in which the device response is evaluated for different imperfection scenarios at every iteration [1], [2]. Such methods have recently been demonstrated successfully for the robust design of a single-frequency mode converter, while accounting for Gaussian-like random sidewall roughness representative of imperfections in realistic lithographically fabricated photonic components [2], [3]. To avoid the high computational cost and challenges of utilizing stochastic sampling methods, we investigate here the efficiency of a stochastic-free broadband optimization approach. Optimization over a broad frequency bandwidth is often assumed and claimed in the literature to yield designs that are more robust against fabrication errors; however, this has not yet been demonstrated systematically. We apply broadband optimization to a mode converter and compare its robustness with that of the stochastic approach from Ref. [2] through a post-optimization cross-validation, in which the final designs are exposed to random “unseen” imperfections. This study aims to establish a deterministic approach for robust TopOpt as a computationally efficient alternative to stochastic approaches.

References

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