Automatic design of high-performance fiber-chip surface grating couplers based on Floquet-Bloch mode analysis

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We propose a new strategy to automatically design highly efficient fiber-chip surface grating couplers. High performance designs are achieved with a substantially reduced computational cost by combining Floquet-Bloch mode analysis with a multi-objective optimization technique (genetic algorithms).

Introduction

Surface grating couplers are nanophotonic structures commonly used in integrated optics for fiber-chip coupling, allowing wafer-scale testing and robust misalignment tolerances. Surface grating couplers are generally designed by re-simulating the entire structure in each step of the optimization process. However, this procedure implies high computational cost, particularly when aiming for high performance which may require optimization of multiple structural parameters.

Methodology and results

We divide the whole structure in two quasi-decoupled electromagnetic problems that can be efficiently solved by analyzing the Floquet-Bloch mode for a single period of the grating with our 2D Fourier expansion tool [1]. Specifically, we first optimize the coupling efficiency (CE) of the periodic structure and then we find the input adaptation section that minimizes back reflections. This way, our technique dramatically reduces the computation time. The proposed technique can be used with any constrained multi-objective optimization procedure, such as genetic algorithms or particle swarm optimization (here the former is applied, see Fig. 1.a). The proposed algorithm is tested by optimizing the grating geometry reported in [2] (see Fig. 1.b), which exhibits a high coupling efficiency. After only 4 hours of computation time, a device with similar peak coupling efficiency and bandwidth as that reported in [2] is obtained.

Conclusions

Our results demonstrate that the proposed optimization procedure can yield devices with state-of-the-art performance automatically, with a minimum designer interaction.

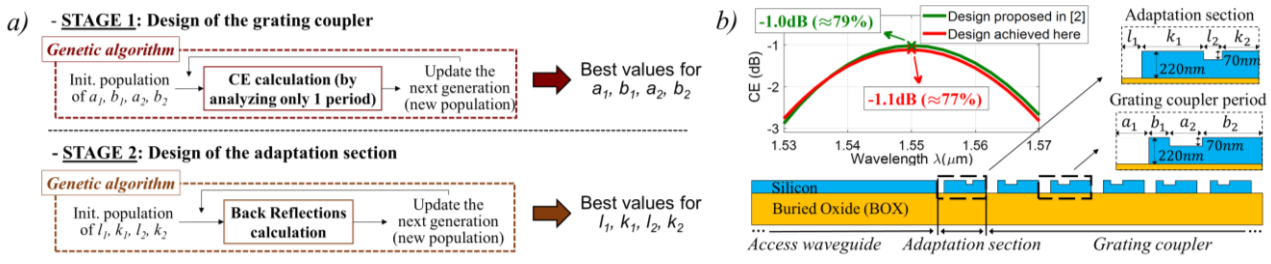

Fig. 1: (a) Automatic design strategy for highly efficient grating couplers and (b) Application example.

References

[1] Zavargo-Peche, L., et al. *Progress Electromagn. Res.* 123, 447 (2012).

[2] Alonso-Ramos, C., et al. *Opt. Lett.* 39, 5351 (2014).