Inverse design for integrated photonic building blocks

Background

For a long time, electronic circuits have dominated the field of integrated circuitry. The possibilities of semiconductor technologies are widely studied and applied on an enormous scale. However, an alternative kind of integrated circuits exists that use transparent materials to guide light from on place to another. Such a system consisting of waveguides is called a photonic integrated circuits (PICs).

The concept of PICs has been first proposed by Miller [1] in 1969. Since then, the field of integrated optics has undergone enormous developments. By now, PICs can be designed that perform increasingly difficult tasks and they are of interested in more and more commercial applications. Examples of applications for PICs include, but are not limited to, on-chip lasers, on-chip amplifiers, or on-chip sensors.

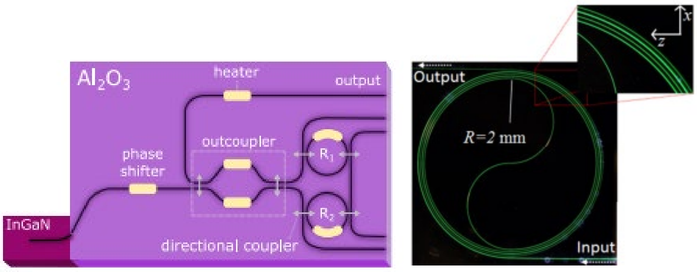

Figure 1 Hybrid integrated near UV lasers [2]   On-chip Er^{3+}:Al_2O_3 spiral amplifier [3]

The performance of waveguides and PICs has been improved over the past years and commercial foundries now exist that can make high quality waveguides, with low propagation losses. Being able to make low-loss waveguides is the first key ingredient to making high performance PICs. However, the performance of PICs can be further improved by reviewing the design process of the basic building blocks that form the full circuit.

To improve the performance of the individual building blocks (such as splitters, combiners, WDMs, MMIs, grating couplers), you want them to be i.e. broadband and polarization insensitive. Furthermore, to achieve high integration density, these building blocks should be as small as possible. To complete these two goals, the principle of inverse design can be applied to the design of photonic integrated circuit building blocks [4]. Inverse design techniques are required since the optimal device design is one that cannot be designed using analytical models or intuitive arguments. These approaches fail particularly whenever more and more complex functionalities are required for the building blocks.

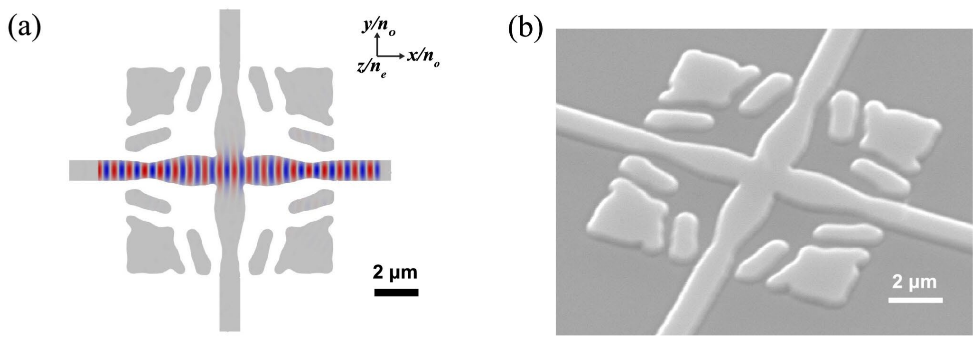

Figure 2 Example of a building block (waveguide crossing) that has been optimised using inverse design methods [4]

Project

The project focuses on setting up a framework that can be used for various inverse design optimisations. While some demonstrations of inverse design processes exists, for instance offered by Lumerical [5], these processes in somewhat limited in possibilities. The existing examples can not be widely applied to any building block.

In this project, the goal is to set up a simulation environment that is able to optimize the performance of any device by defining the inputs, outputs and the performance requirements. Based on a learning algorithm of choice, the performance of a building block needs to be optimized. To verify if the designed devices work as envisioned, the building blocks can be fabricated in the cleanroom. These devices can me characterized in the optical lab to see if simulation and characterisation match.

Contact

If you are interested in the topic of inverse design for photonic building blocks, or if you are looking for more information about possible (other) assignments, feel free to contact:

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[5] Photonic Inverse Design (lumerical.com)