Efficient Tool for Bend Optimization in Photonic Crystals

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The realization of efficient sharp and compact waveguide bends is still a challenging task in microoptics. With the introduction of photonic crystals (PC) major interest has also focused on the issue of efficient waveguide bends embedded in PC. There are various proposals for bend design in order to minimize losses. Examples smoothening the sharp bends, introducing cavities or intermediate straight sections or placing smaller holes around the bend.

In this work we use the method of topology optimization to maximize the energy flow through the waveguide and thus reduce unwanted reflections from the waveguide bend to a minimum. We specify a design area in the vicinity of the waveguide and distribute the material in this domain to maximize the energy flow. The flow through the waveguide is found by computing the poynting vector at the output waveguide port.

We have demonstrated 1.55 μm wavelength light wave through a simple 90° sharply bent waveguide formed in a square lattice two dimensional photonic crystal (2DPC). The in-plane guiding within the planar PC structure is based on a W1 defect waveguide (A single line defect acting as a light channel in the $G-K$-direction) whereas for the vertical light confinement we rely in a slab waveguide formed by the low index contrast material system InGaAsP/InP. To achieve a reasonable bandgap around 1.55 μm the PC consists of a lattice of holes with a filling factor of 40%. Such propagation has not previously been experimentally confirmed.

The most promising structure was simulated with a 2D-FDTD program. Since we want to use this device around 1550 nm we calculate the lattice constant to be 430 nm and obtain therefore a hole radius of 141.9 nm respectively.

This optimization step has resulted in 2DPC bend that shows a power transmission of at least 100% over a wavelength of 1550 nm.