OptiMode

Waveguide Modal Analysis Software

Polarization Splitter with Holey Fibers

using the Vector Finite Element Method

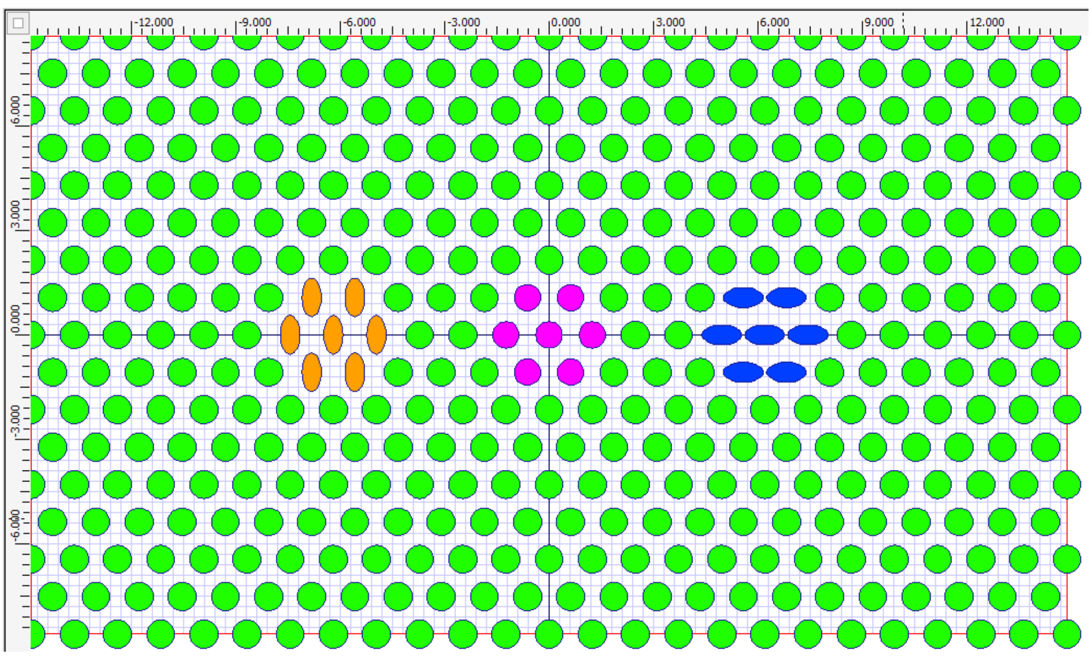
Applications

- Passive optics
- Single-polarization transmission
- Polarization splitters
- Photonic crystal fibers
- Polarization division multiplexing
- Dispersion control

Overview

Elliptical-hole core circular-hole holey fibers (EC-CHFs) can be engineered to provide absolutely single polarization transmission [1]. Along with a more conventional circular-hole core circular-holey fiber (CC-CHF), a polarization splitter can be designed that will couple light from an incident CC-CHF into either an EC-CHF that supports an *x*-polarized mode or into another EC-CHF that supports a *y*-polarized mode, such as the structure presented below.

Scripted Layout Generation



Benefits

- The Vector Finite Element Method (VFEM) is extraordinarily accurate in calculating all electromagnetic field components and approximating geometry, which is of utmost importance in photonic crystal fibers

- Uniaxial perfectly matched layers (UPML) can be used to find leaky modes

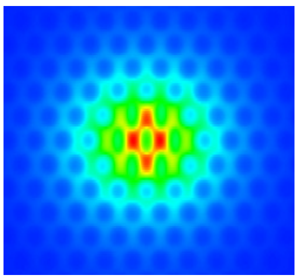
- Triangular mesh size can be adapted to accurately approximate electromagnetic field and waveguide geometry

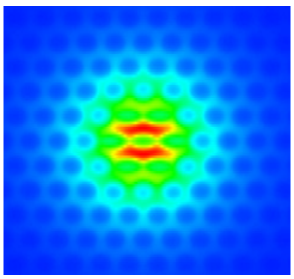
- Exploiting the symmetry of the waveguide, the simulation domain can be reduced and modes with certain symmetries can be targeted

Simulation Description

The goal of the reference [1] was to design a polarization splitter with the layout given on the reverse side. The splitter is made up of 3 separate holey fibers. The two outer holey fibers each support a single polarization, while the center structure supports both polarizations. Incident light will selectively couple to either one of the outer holey fibers depending on its polarization.

The first step of the procedure is to phase match the modes of each structure to reduce any reflections [1]. The different structures must share some properties, like pitch and cladding atoms. Within the core of each structure, there is freedom in choosing the size and shape of the holes.


(*a*)


(*b*)

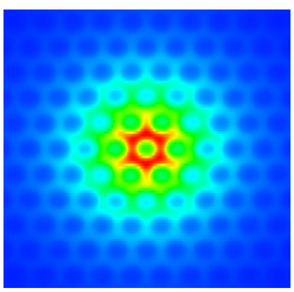

(*c*)

Figure 1: Dominant magnetic field distribution for each type of core. (a) yEC-CHF, (b) xEC-CHF, (c) CC-CHF

Using the properties given in [1], the modal indices of the three different cores were calculated with OptiMode and recorded in Table 1. These results provide excellent agreement with the results demonstrated in [1], where all three structures share the modal index of 1.31043.

Table 1: Modal indices of single core structures

Structure	Modal index OptiMODE	Zhang *et al.* [1]
CC-CHF	1.31043	1.31043
*x*EC-CHF	1.31041	1.31043
*y*EC-CHF	1.31043	1.31043

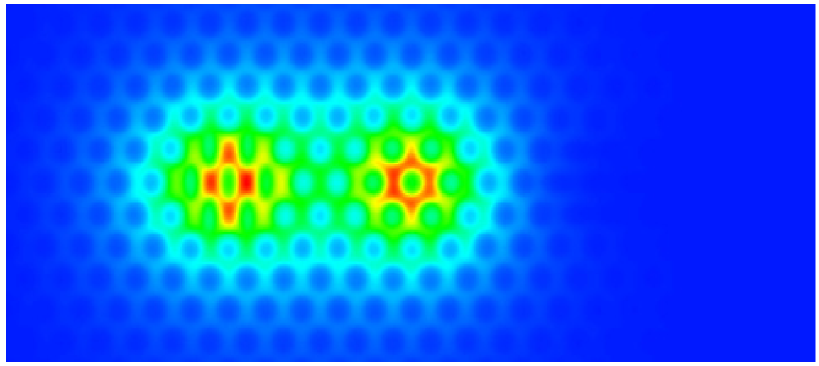


Figure 2: Magnetic field distribution of superstructure's even mode y-polarization

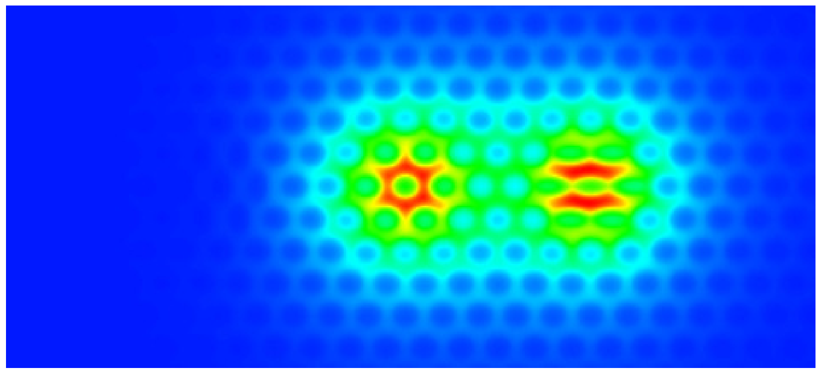


Figure 3: Magnetic field distribution of superstructure's even mode x-polarization

Putting the three cores together into a superstructure, results in a waveguiding structure that supports both polarizations, with each polarization having even and odd modal solutions. The even modal solutions are presented in Figure 2 and Figure 3. The coupling length is then given by:

$$L_c = \frac{0.5\lambda}{n_{even} - n_{odd}}$$

where n_{even} and n_{odd} are the modal indices of the even and odd modes [1]. The coupling lengths calculated with OptiMODE are compared to those of [1] in Table 2.

Table 2: Coupling length of polarization splitter

Polarization	L_c (μm) OptiMODE	L_c (μm) Zhang *et al.* [1]
x-pol	642	638
y-pol	619	622

These results confirm that the VFEM mode solver in OptiMode can be used to design and simulate holey fiber type structures confidently and accurately.

References

[1] Z. Zhang, Y. Tsuji, and M. Eguchi, "Design of Polarization Splitter With Single-Polarized Elliptical-Hole Core Circular-Hole Holey Fibers," *IEEE Photonics Technol. Lett.*, vol. 26, no. 6, pp. 541–543, Mar. 2014.