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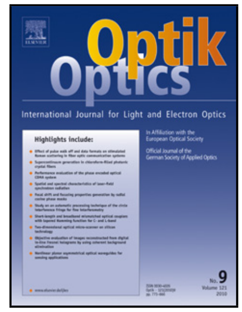

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Design and analysis of polarization splitter based on dual-core photonic crystal fiber

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Abstract

A design of polarization splitter with dual-core photonic crystal fiber (DC-PCF) has been proposed. By using a finite-element method, the incident polarized light can be split into two orthogonal single-polarization states (x-polarization and y-polarization) through the proposed polarization splitter. Numerical results show the bandwidths of the x-polarization and y-polarization modes are 100 nm and 55 nm at the wavelength of 1.5 µm. The length of the designed DC-PCF is 2 mm and the extinction ratios of the x-polarization and y-polarization modes are -52.5 dB and -32.85 dB at the wavelength of 1.5 µm, respectively. This study will be very helpful to design and manufacture a splitter based on DC-PCF for better performance.

Index terms: Dual-core photonic crystal fiber (DC-PCF), Polarization splitter, Finite element method (FEM)

Introduction

Optical fiber communication systems as well as optical devices are subjects of growing interest due to its extremely attractive characteristics. Moreover, the rapid advancements in technology has transcendent the most optimistic predictions, creating more advantages [1]. Photonic crystal fibers (PCFs) are micro-structured optical fiber, which are formed by single material with multiple air holes periodically arranged around the core [2]. PCFs [3–4] have been investigated widely and deeply in the last decades due to their fantastic features and promising potential applications. The PCFs are mainly divided into two classes: the photonic bandgap fiber and the air-silica index-guiding fiber. The latter utilizes the modified internal reflection principle [5-12] and forms cores with absence of the air holes. The air-hole array acts as the fiber cladding with an average refractive index lower than the silica core. Thus the regularly distributed air-hole array is not necessary, which brings more possibilities to design new fiber structures. The index-guiding PCFs exhibit many unique properties of light guidance, such as single-mode operation over a wide range of wavelengths [5], highly adjustable effective mode area and nonlinearity [6-8], the dispersion at visible and near-infrared wavelengths [9-12] and so on.

The PCFs can be made highly birefringent due to a sharp index contrast between air and silica. The photonic crystal fibers have exhibited their potential to realize high performance polarization-relative components including polarization maintaining fibers (PMFs) [13-16] and

polarization splitters [17-19]. Some PMFs employ asymmetric air-hole distribution near the fiber core to produce a high birefringence [13-15]. The strong wavelength dependency of the effective refractive index and the inherently large design flexibility of the PCFs allow for a whole new range of novel properties. Such properties include endlessly single-mode fibers, extremely nonlinear fibers and fibers with anomalous dispersion in the visible wavelength region [7-8]. They could serve as a fiber host for developing a wide range of fiber devices for high power fiber laser, second harmonic generation, polarization beam splitter, super continuum generation, radiation detection, etc. PCFs may be divided into two categories [9]: high index guiding fibers and low index guiding fibers. Similar to conventional fibers, high index guiding fibers (solid core) are guiding light in a solid core by the modified total internal reflection (M-TIR) principle. The total internal reflection is caused by the lower effective index in the micro structured air-filled region. PCFs are of great interest for optical communication and for new optical devices. Many functional devices utilizing phonic crystals (PCs) have been proposed and are expected to play an important role in future optical circuit. Components being used in planar optical circuits include couplers, de/multiplexers, power-splitters, cavities, etc., and they can be also realized in 2-dimensional (2D) PC slab structures [20]. The devices on the 2D PC slab have many advantages such as relatively easy fabrication and convenient integration into conventional devices. Recently, well-established silicon-on-insulator (SOI) process facilitates the fabrication of 2D PC slab devices with much improved accuracy [21]. Polarization beam splitters, that can split one light into two orthogonal polarization states, are one of essential components in optical fiber communications and integrated photonics. Various types of optical polarization splitters have been proposed [22-26].

Structure and Theory

Designed PCF is formed by two different sizes of elliptical air holes and two large elliptical air holes are removed for forming a dual core. Some parameters are considerable one, such as (1) pitch/gap (2) air hole diameter (3) refractive index (RI) of filled material. Background is filled with pure silica material and the remaining holes are filled with air. It is basically designed with