Abstract

The rapid development of photonic crystals (PhC), photonic crystal fibers (PCFs) and photonic bandgap fibers (PBFs) since the last decade has created strong requirements for novel optical components that can handle functions such as endlessly single mode operation, dispersion compensation, flattened dispersion, photonic crystal ring resonator, add-drop multiplexer, power splitters and sensors. The artificial crystal-like structure of PCFs results in a number of unique and unusual properties, such as single mode operation from UV to IR spectral regions, large mode areas with core diameters larger than 20 m^2, highly nonlinear performance, tunable dispersion, and a numerical aperture ranging from arbitrarily low value to 0.9, impossible to achieve in classical step index fibers. Therefore, PhCs, PCFs and PBFs offer exciting potentials for key enabling technologies in optical communication systems, such as chromatic dispersion compensators, optical memory, optical components such as ring resonators, add-drop multiplexers and different sensing applications like temperature, pressure, strain, chemical, humidity, etc.

This thesis proposes an all-glass photonic crystal fiber (AGPCF) and an all-glass photonic bandgap fiber (AGPBF) structures in which air-holes are replaced by doped silica rods in the cladding region to reduce the various difficulties such as deformation of air-holes and emergence of additional holes encountered during the fabrication of air-hole PCF's and air-hole PBF's. The proposed all-glass photonic crystal fiber structures are analyzed for endlessly single mode (ESM) regime and tunable dispersion properties. The proposed AGPCF structure exhibits ESM property for higher value of d/Λ when compared to conventional PCFs. The proposed structures are analyzed for dispersion compensation (-600 ps/nm/km), dispersion shifting (to any desired wavelength) and flattened dispersion of the order of +/- 0.2 ps/nm/km over a wavelength range of 1400 nm to 1650 nm. It also estimates the different types of the losses using plane wave expansion (PWE) and finite difference time domain (FDTD) methods in the proposed design and results indicate that the losses in the proposed structure are in between that of single mode fiber and the conventional photonic crystal fiber. The dispersion properties are analyzed in the proposed AGPBF structure along with confinement loss. Result indicate that the proposed AGPBF has tunable dispersion property and the confinement loss can be minimized by increasing the doping concentration.

Further, the different optical components are designed, which are required for the all-optical networks (AON) such as; ring resonator, add-drop multiplexer (ADM) and splitter. Numerical analysis of the proposed ADM is done with finite difference time domain method and results shows that the proposed structure has excellent coupling and dropping efficiency. Also proposed and analyzed temperature and strain sensors using all-glass photonic crystal fiber.

Keywords: All-glass photonic crystal fiber, endlessly single mode, doping, dispersion, all-glass photonic bandgap fiber, photonic bandgap, ring resonator, add-drop multiplexer, power splitters and sensors.