Characterization of photonic crystal fibers by using a full-vectorial finite element method

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The photonic crystal fiber (PCF), which is also known as holey fiber, is a micro-structured fiber, where arrays of holes running along the waveguide length, has more controllable fabrication parameters than standard single mode fiber. Increasing interest is being shown in such PCFs for a range of applications in optical communications, sensing and signal processing. This has included the control and guidance of optical beams, taking advantage of their unique transmission characteristics, including being continuously single-moded, with controllable spot-sizes offering large spot size for high power delivery and small spot size for intense nonlinear activities. The fibers also allow tailored group velocity dispersion characteristics for various linear and nonlinear device applications.

To date, most of the research into these fibers has a strong experimental basis [1], which has recently been complemented by various modal solution approaches to their characterization, this having mostly been using scalar formulations or being limited to specific types of structures. The modal solution approach based on the powerful finite-element method (FEM) [2] is more flexible, can represent any arbitrary cross-section more accurately and has been widely used to find the modal solutions of a wide range of optical waveguides [2]. The flexibility of the FEM to represent a cross-section of a holey fiber, with its arbitrary hole sizes, materials, shapes, and their placement, makes it a powerful approach where many other simpler and semi-analytical approaches are proven to be unsatisfactory. The optical modes in a high-index contrast PCF with two-dimensional optical confinement are also hybrid in nature, with all six components of the E and H fields being present. To characterize accurately such fibers, a full-vectorial approach is necessary and such a H-field based full vectorial approach [2] has recently been extended to study the polarization issues in PCFs.

Modal solutions for the fundamental and higher order TE and TM polarized modes have been obtained including the variation of the propagation properties, the modal field profiles, spot-size, power confinement and the modal hybridism. An asymmetric air-hole has been introduced into the designs to enhance the modal birefringence and to create a single polarization PCF. Bending loss and mode degeneration will be presented along with the design of optical polarizer using PCF. The use of defect-core and metal coating to excite surface plasmon modes and their applications as sensors at both optical and terahertz frequencies will be presented.

REFERENCES