Emerging fiber components for lightwave communications

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Abstract

Recent developments in the fabrication of one and two dimensional microstructured optical fiber devices are reviewed. A range of possible applications within future communications systems are described.

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Fiber fabrication and post-fabrication processing methods have advanced significantly over the past few years, allowing the development of complex, microstructured fibers and fiber components suitable for a wide range of telecommunication applications. To highlight the potential of current microstructuring technology and the range of possible applications of microstructured fiber components we review our recent activities and achievements in the three key areas described below.

Fiber Bragg Gratings (FBGs)

FBGs- i.e. fibers with a weak, periodic 1-D microstructuring of the refractive index of the core are perhaps the most familiar and advanced form of microstructured fiber device. FBGs are already finding widespread application in commmunications for familiar functions such as filtering, add-drop multiplexing and dispersion compensation. As a result the technology has evolved to the extent that grating structures can now be written with almost arbitrary control of the phase and amplitude of the refractive index modulation profile over metre long length scales[1]. Whilst this capability obviously allows for improvements in conventional FBG devices it also opens up the possibility of using FBGs for more advanced functions. For example one can use FBGs for pulse shaping/coherent control applications. To highlight this we recently demonstrated optical code generation and recognition using a superstructure FBG. The technique has potential for use in OCDMA/high speed network applications [2].

Holey Fibers

As well as patterning the refractive index of a fiber in the axial direction it is now possible to fabricate fibers with complex transverse (2 D) structure. This is most easily achieved by stacking hollow capillaries and pulling the resultant air:glass structures down to fiber dimensions [3]. Such fibers, commonly called holey fibers, thus contain microscopic arrays of air holes that run along the entire fiber length and which define their guidance properties. Holey fibres can be designed to provide single-mode guidance through volume average refractive index profiling or 2D photonic bandgap effects, although the latter has yet to be demonstrated experimentally. These fibers offer a wide range of unique optical properties of interest for telecommunications applications. For example it is possible to develop holey fibers with high normal dispersion (~500ps/nm/km) suitable for dispersion compensation applications, large mode area dispersion-shifted and dispersion-flattened fibers, as well as fibers with high/low optical nonlinearity [4].

Quasi Phase Matched (QPM), poled fibers

Using poling it is possible to produce permanent and large (>1pm/V) second order nonlinearities in bulk glass and glass waveguides[5]. The fabrication of QPM, second-order nonlinear fiber gratings is ideal for a wide range of QPM processes and can be achieved using thermal poling with periodic electrode structures defined on D-shaped fibers using standard lithographic techniques. Fabrication of such gratings has now progressed to the point that peak second harmonic conversion efficiencies as high as 30% at 1550nm have been obtained [6]. Such results put fibers in the frame as serious contenders to QPM ferroelectrics such as periodically-poled lithium niobate (PPLN) for frequency conversion, phase conjugation and nonlinear switching applications.

In conclusion, as the above examples serve to illustrate, microstructured fiber components promise to play an important role in future communication systems.

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