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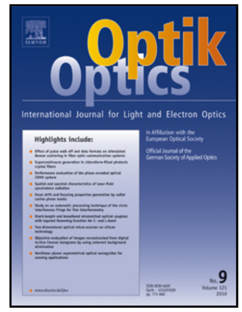

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DESIGN AND ANALYSIS OF BROADBAND SINGLE-MODE PHOTONIC CRYSTAL FIBER FOR TRANSMISSION WINDOWS OF THE TELECOM WAVELENGTHS

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Abstract: To analyse the convenient use of photonic crystal fiber in the communication windows, a broadband single-mode photonic crystal fiber is proposed based on index-matching resonant coupling by using the full vector finite-element method. The novel microstructured design has been achieved for a wavelength range of 1.3 μm to 1.6 μm. Thus it provides a wide operational bandwidth of 300 nm. This bandwidth covers all the transmission windows of fiber-optic communication except that of 'first window'. The higher order mode resonant coupling losses of the proposed fiber are good enough within this wavelength range to maintain the single mode operation. The mode field area for the proposed fiber in straight and as well as bent state is enough such that the fiber can reduce the optical intensities, which makes the fiber to be useful in high power fiber lasers and the amplifier applications. The proposed fiber exhibits a very small fundamental mode loss below 10^{-3} dB/m both in the straight and bent state. Moreover, the broadband design which covers the most widely used second and third communication windows of wavelengths around 1310 nm and 1550 nm respectively, will draw the attention of the manufacturer in the fiber optic communication.

Keywords: Index-matching coupling; optical fiber communication windows; fiber waveguide confinement loss and bending loss; higher order mode suppression; single-mode photonic crystal fiber (PCF).

1. INTRODUCTION

Recently, photonic crystal fibers (PCFs), also known as microstructured optical fibers or holey fibers have attracted a great attention because they can provide unprecedented degrees of freedom in tailoring their modal properties [1]. Such characteristics of PCFs have sparked growing interest in their use in many fields, from theory to applications. Initially in early 1970s due to technology limitation, the fiber-optic communication started in the 800 nm band which was also termed as 'First-window'. After the glass purification technology improved, in 1980s the communication shifted to the 1300 nm band, so called the 'Second Window'. In 1990s the communication was shifted to 1550nm window, so called 'Third Window' or 'erbium window' due to the invention of the EDFA (Erbium Doped Fiber Amplifier). However, challenges still exist especially in the way to deal with fiber nonlinearity induced by the high power. In case of the high power devices, the primary constraint which degrade the performance is the nonlinear effects. Among these effects, the self-phase modulation (SPM) changes the dispersive behaviour in the high bit-rate transmission system whereas the stimulated Raman-scattering (SRS) and stimulated Brillouin scattering (SBS) decrease the signal-to-noise ratio. Furthermore, SRS and four-wave mixing (FWM) are the two major nonlinear effects that increase the crosstalk between the different WDM systems. Fibers with large mode area (LMA) provide the most effective solution to the issue because the fiber nonlinearity is inversely proportional to mode field area and also it supports a high transmission in the fiber laser and amplifiers [2, 3]. Due to the reduced optical intensities, such fibers effectively have lower nonlinearities and higher damage threshold which makes them suitable in fiber amplifiers.