МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ
РАДІОЕЛЕКТРОНІКИ

МАТЕРІАЛИ
XX ЮВІЛЕЙНОГО МІЖНАРОДНОГО
МОЛОДІЖНОГО ФОРУМУ

РАДІОЕЛЕКТРОНІКА ТА МОЛОДЬ У XXI СТОЛІТТІ

Том 1

Харків 2016

PHOTONIC CRYSTAL FIBERS TECHNOLOGY DEVELOPMENT OPPORTUNITIES IN COMMUNICATIONS SYSTEMS

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In communication the fibers could provide many new solutions. The photonic crystal fibers offer the possibility of low losses and dispersion, a possible competitor to conventional fibers. For photonic crystal fibers to realize their potential and advantages over conventional fibers in fiber optic communication. Thus, Photonic crystal fibers play the key role in the development of novel fibre-laser sources of ultrashort light pulses and creation of fibre-format components for the control of such pulses. In this paper we will discuss the photonic crystal fibers technology development opportunities in the field of communications systems.

Photonic crystal fibres (PCFs)

Photonic crystals are periodic structures of dielectric materials and can today be produced with almost any imaginable structure. In PCFs, radiation can be transmitted through hollow core, surrounded with a microstructured cladding, consisting of an array of cylindrical air holes running along the fibre axis. Such a microstructure is usually fabricated by drawing a perform composed of capillary tubes and solid silica rods. Along with conventional waveguide regimes, provided by total internal reflection, PCFs under certain conditions can support guided modes of electromagnetic radiation due to the high reflectivity of their cladding within photonic band-gaps (PBGs) or regions of low densities of photonic states [1], as well as by the antiresonance mechanism of waveguiding [2]. Such regimes can be supported by fibres with a hollow [3] core and a two-dimensionally periodic (photonic crystal) cladding. A high reflectivity provided by the PBGs in the transmission of such a cladding confines radiation in a hollow core, substantially reducing the loss, which is typical of hollow-core-guided modes in conventional, capillary-type hollow waveguides and which rapidly grow with a decrease in the diameter of the hollow core [4].

Optical fiber communication system

An optical fiber communication system is similar in basic concept to any type of communication system. A communication system is to convey the signal from the information over the transmission medium (photonic crystal fiber) to the destination. The communication system is consists of a transmitter, the transmission medium, and a receiver or demodulator at the destination point. For optical fiber communications the information source provides an electrical signal to a transmitter comprising an electrical stage which drives an optical source to give modulation of the light wave carrier. The optical source which provides the electrical–optical conversion may be either a semiconductor IR . The transmission medium consists of an photonic crystal fiber and the receiver consists of an optical detector which drives a further electrical stage and hence provides demodulation of the optical carrier. Photodiodes in some instances, phototransistors and photoconductors are utilized for the detection of the optical signal and the optical–electrical conversion. Thus there is a requirement for electrical interfacing at either end of the optical link and at present the signal processing is usually performed electrically.

Calculation of the propagation

The spacing between the air holes in a photonic crystal structure with air holes embedded in dielectric material is given roughly by the wavelength of the light divided by the refractive index of the dielectric material. The problem in making these small structures is enhanced because it is more favorable for a photonic band gap to form in dielectrics with a high refractive index, which reduces the size of the lattice spacing even further. The magnetic and electric fields are related by

$$E_{\omega}(r) = -\frac{ic}{\omega\varepsilon(x,y)}\nabla \times H_{\omega}(r), \tag{1}$$

Where with translational symmetry $\varepsilon(x, y)$ is independent of z. Consequently, $E_{\omega}(r)$ also fulfills Eq. (1). The emitting power of the light (IR) from the transmitter may take many reflected and refracted paths before arriving at the receiver. The receiver in an optical communication system is the light detector (photodiode). The large size of the photodiode with respect to the wavelength of the light provides a degree of inherent spatial diversity in the receiver which mitigates the impact of multipath fading. Multipath fading is not a major impediment to optical communication, temporal dispersion of the received signal due to multipath propagation remains a problem. This dispersion is often modelled as a linear time invariant system since the channel properties change slowly over many symbol periods [5]. The impact of multipath dispersion is most noticeable in diffuse infrared communication systems. Unlike conventional fiber optical systems, multipath fading is not a major impairment in photonic crystal fiber transmission. The multipath propagation of light produces fades in the amplitude of the received electromagnetic signal at spacings on the order of half a wavelength apart. The figure (1) illustrates the distribution and attenuation photonic crystal fibers with diameter 10μm.

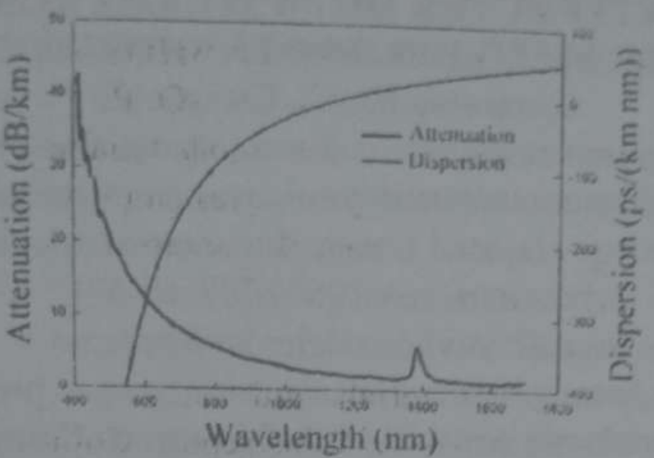

Figure 1. – Distribution and attenuation of the output power with a hollow core photonic crystal fibers

Conclusion

The transverse micro-structuring makes the dispersion of the fibers highly tunable and together with the high index contrast it leads to the small effective area, cade of nonlinear effects can take place in the fibers. The interplay between the special dispersion of the fibers and these nonlinear effects makes the phenomenon of supercontinuum generation possible. The full frequency dependency of the propagation constant as well as the effective transverse area serve as input for the model and these parameters can either be calculated as measured. Low loss per unit length, to satisfy the optical power budget allocation for fiber loss and low backscatter, to prevent noise and associated measurement error. The low nonlinearities, such as the Kerr effect, whereby refractive index dependencies in the light-guiding material due to electric field can cause a non-reciprocal effect in the fiber loop leading to measurement error.

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