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On the Propagation through Twisted Clad Optical Fibers

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1. Introduction

Electromagnetic response of complex structured optical waveguides has been attracted the R&D communities. Behavior of electromagnetic waves is altered upon changes introduced in geometrical and/or structural properties of material, construction of medium and nature of the excited field. Within the context, several forms of complex structured optical waveguides with different cross-sectional and/or material properties [1–5] have been explored. Twisted clad optical fiber is also nominated as complex structure waveguides that owe interesting phenomena by altering pitch angle of twist. The fundamental fact is that the pitch angle of twisted optical fiber plays a deterministic role in the control of flux density and power through the guide [4–6].

In the present work, we investigate the propagation behavior of normalized power corresponding to lower order EH_{01} mode through twisted clad optical fiber. Studies are made under varying pitch angle of twist as well as different wavelengths of the excited field.

2. Theory and Discussion

We consider a twisted clad optical fiber with circular cross-section and having its core radius as 5 μm; the outer clad region being of infinitely extended in nature. The refractive indices of core and clad regions are takes as 1.462 and 1.4568, respectively. The fiber is excited with time t- harmonic (i.e. $e^{\iota\omega t}$) and +z-harmonic waves. The axial component of electromagnetic field is written as

$$E_z = E(r,\varphi)e^{\iota(\omega t-\beta z+v\varphi)} \tag{1a}$$

$$H_z = H(r,\varphi)e^{\iota(\omega t-\beta z+v\varphi)} \tag{1b}$$

In eq. (1) 1, ω is the angular frequency, β is the propagation constant and v is the azimuthal mode index.

We have investigated the normalized power through the core and the clad sections for different wavelengths of the excited field, by altering twisted clad pitch angle. Figures 1 and 2 demonstrate the behavior of normalized power through the core region of the guide corresponding to the values of pitch angle as 0º and 90º, respectively. Figures 1a and 2a illustrate the propagation pattern of the normalized power Γ(core) corresponding to lower order EH_{01} mode through core section. It becomes obvious that the behavior of power through the fiber core is similar for different values of operating wavelengths. Also, the power confinement in the core section is increased by increasing the value of propagation constant β. The maximum amount of power confinement is observed for $\beta = 5.888\times10^{6}\ m^{-1}$, and the confinement is minimized when $\beta = 5.872\times10^{6}\ m^{-1}$. Figures 1b and 2b, respectively, show the normalized power confinement Δ(clad) through the clad section of the guide under consideration corresponding to 0º and 90º twists. It can be observed that the power confinement behavior in the clad section is the complement of what has been observed for the confinement through the core region. Moreover, while the confinement in the core region is increased, it is minimized in the clad region corresponding to the situation when the pitch angle is adjusted to 0º – the case when the twists are perpendicular to the optical axis.

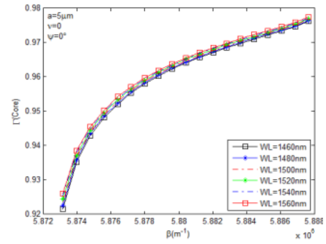

Fig. 1a. Variation of confinement in core corresponding to ψ = 0°.

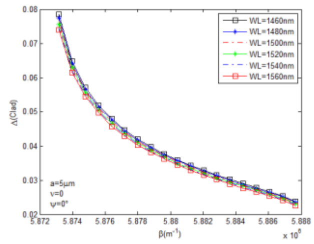

Fig. 1b. Variation of confinement in clad corresponding to ψ = 0°.

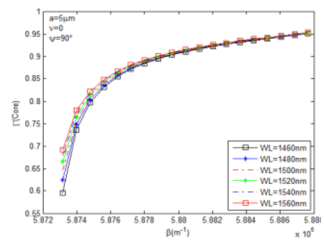

Fig. 2a. Variation of confinement in core corresponding to ψ = 90°.

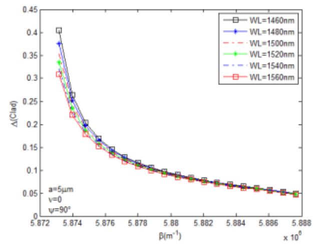

Fig. 2b. Variation of confinement in clad corresponding to ψ = 90°.

Conclusion

Normalized power patterns through the core/clad sections of optical fiber has been analyzed by altering the pitch angle of twists. Additionally, the power pattern is studied for different wavelengths of excited field. Investigations reveal that, by altering pitch angle as well as propagation constant, power confinement patterns can be tailored, which would find prominent optical applications.

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