Magnetic Photonic Crystal Fiber Based on YIG Infiltrated with an Applied External Magnetic Field

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Abstract:

Photonic crystals (Phcs) have attracted increasing attention, due to their unique property of directing and manipulating light at the micro/nano dimension. Phcs are dielectric structures with a period comparable to the optical wavelength. The major attraction of these structures is the appearance of the photonic bandgap. Recently, magnetic materials have been incorporated in Phcs, which has led to new properties such as the non-reciprocity, which can be adjusted by the application of a magnetic field through magneto-optical (MO) effects. Magnetophotonic crystals are widely applied for high-sensitive sensors and MO isolators. In the other hand, ferrite materials with garnet structures are magnetic materials that have an impact on the electronics industry because of their application in diverse technological fields and devices. The efficiency and performance of these devices have been improved using ferrites such yttrium iron garnet ($Y_3Fe_5O_{12}$ or YIG). They have interesting properties such as large Faraday rotation and tunable optical properties under an external applied magnetic field (H_{ex}), this latter leads to the appearance of the off-diagonal elements (gyrotropy) in the dielectric permittivity tensor. In recent years, the magnetic fluid (MF), which has both the fluid characteristics of liquids and the magnetic properties of solids, displays a variety of MO characteristics. Compared with the conventional devices, MF-based optical devices have the advantages of high sensitivity and easy controllability. All these features make them promising for wide range of technology applications in the fields of photonics and sensing. In this work, a kind of magnetic Phc fiber is proposed. This device consists of a triangular lattice of air holes filled with MF (Fe_3O_4) at H_{ex} strength of 271 Oe and temperature T = 24.3 °C in YIG fiber with a refractive index n_{yig} = 2.28. A numerical study using the Beam Propagation Method has been established to investigate the MO properties. As known, the optimization of the maximum rate of the TE-TM mode conversion imposes a reduction of the polarization-independent which is directly related to modal birefringence (Δn). Figure 1 represents the variation of Faraday rotation (θ_F) and modal birefringence as a function of gyrotropy (g) at λ = 1.55 μm. A linear relationship between θ_F

and g is observed: θ_F increases from 1528.4023(4) °/cm to 6451.4122(0) °/cm with the increase of g from 0.0030 and 0.0125, respectively. Additionally, the variation of the modal birefringence in function of gyrotropy is also plotted in the same Fig. 1 where Δn increases when the gyrotropy increases from $\Delta n = 2.342\times10^{-6}$ to $\Delta n = 92.73\times10^{-6}$ for $g = 0.003$ and $g = 0.0115$. It is concluded that this structure helps to improve the MO performance, such as the increasing of Faraday rotation and mode conversion as well as the decreasing of modal birefringence and losses.

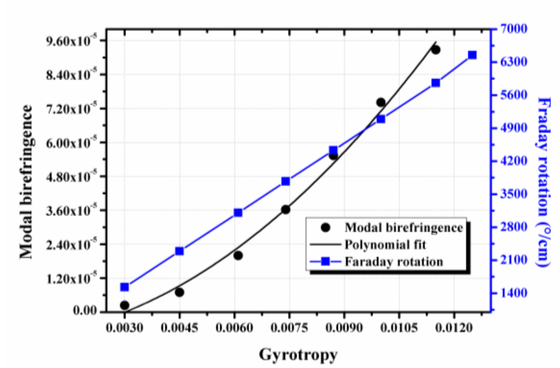

Fig. 1. Faraday rotation and modal birefringence versus the gyrotropy for TE mode polarization.

Biography:

Mahieddine Lahoubi was born in Algiers, Algeria, in 1957. He joins Badji-Mokhtar Annaba University, Algeria as a full Professor in the Department of Physics. He received his doctorate of state in Physics in 1986 from Joseph Fourier University of Grenoble, France with thesis research prepared at the Laboratory Louis Néel. He has authored or coauthored over 55 peer-reviewed papers in international journals and he has had the opportunity to participate in several international conferences and meetings in Magnetic Materials (Intermag, ICM) and Neutron Scattering (ECNS) as well as those in Superconding and Non-Superconducting Materials (EUCAS) and Magnetic Sensors (EMSA), …. He has the status of an Individual Member of the European Rare Earth and Actinide Society (ERES), Lausanne, Switzerland, since 1999. He has developed new courses in solid state physics and introduced the fundamental bases of magnetism since 1987 when he was a teaching Assistant Professor. His primary research interests are in the field of magnetism and magnetic materials especially the study of rare earth iron garnets by using neutron diffraction and high magnetic field magnetization experiments as well as the low-temperature thermal and magnetic properties of PrBCO cuprates. Now, his current research interests include optical properties of photonic and magnetophotonic devices.