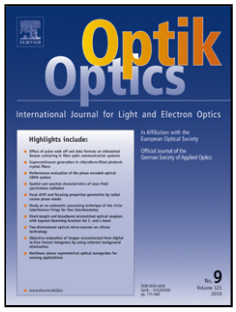

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A novel optical fiber magnetic field sensor based on Mach-Zehnder Interferometer integrated with magnetic fluid

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Abstract
In this paper, a novel Magnetic fluid-filled optical fiber sensor consisting of a multimode-single mode-multimode (MM-SM-MM) fiber structure has been proposed and experimentally demonstrated. The proposed sensor is based on a Mach-Zehnder interferometer, which is fabricated by splicing a section of uncoated single mode fiber between two short sections of multimode fibers with a fiber fusion splicer. The micro-structure is sealed in a Magnetic fluid-filled capillary tube and the magnetic field sensing probe is formed. Variations in an external magnetic field is seen to cause changes in the refractive index of MF. This tunable change in the refractive index with magnetic field strengths between 0.6 mT to 21.4 mT produces a shift in the position of the peak of the wavelength. The shift of the valley wavelength with magnetic field intensity has a good linearity of up to 99.586%. The achieved sensitivity of the proposed magnetic field sensor is 0.12306 nm/mT. Furthermore, we also proposed the corresponding building methods of the measurement system based on the MM-SM-MM structure. It turned out that a voltage change indirectly reflects the change of the external magnetic field strength. This therefore provides the potential to fiber-based magnetic field sensing applications.

Keywords: fiber optics ; Mach–Zehnder interferometry; magnetic fluid; magnetic field sensor

1. Introduction

Over the last three decades, the magnetic fluid (MF)-enhanced all-fiber magnetic field sensor has been widely studied and developed. Compared with traditonal sensors, optical fiber magnetic field sensors have several superior performances such as: immunity to electromagnetic interference; having a simple fabrication process; being alignment-free; having low maintenance requirements; adapting to harsh environments and remote sensing, etc. [1-3]. For fiber-based magnetic field sensors, the magneto-optical materials are the key elements to response the magnetic field. Magnetic fluid (MF) is a kind of stable colloidal solution consisting essentially of surfactant-coated magnetic nanoparticles stably dispersed in a suitable liquid carrier. It possesses versatile magneto-optical properties, such as the Faraday Effect, tunable refractive index, birefringence, thermal lens effect and linear dichroism etc. [4, 5]. Currently, the optical fiber based refractometers combined with the fine-controllability of the refractive index (RI) of MF under the variable magnetic field have been extensively investigated. For instance, using fiber Bragg gratings [6], etched and tapered fiber [7-9], D-shaped fibers [10], core-offset and up-tapered fibers [11-13], no core fibers [14] and photonic crystal fibers (PCF) [15, 16] and a series of optical fiber interferometers based on Mach-Zehnder interference (MZI) [15,17], Fabry-Perot interference [18-20], Sagnac interference [21-23] and Multimode interference. Some experimental phenomena are