PHOTONIC CRYSTAL FIBER MAGNETIC FIELD SENSOR BASED ON AMPERE FORCE

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ABSTRACT: *Magnetic field PCF modal interferometer sensor based on Ampere force is proposed . We fabricated this sensor by splicing section of PCF between two SMFs to achieved Mach-Zehnder interferometer. Ampere force is generated When electrical current flow in AL wire passes perpendicular magnetic field applied. It leads to vibration AL wire is installed with PCF. Cladding mode of PCF is sensitive to external effect. The magnetic field varies in range from (5.2mT) to (31.7mT). The greatest value of the sensitivity of this sensor reached equal to (31.2pm/mT).*

Keywords: photonic crystal fiber; magnetic field sensor; Ampere force; Mach-Zehnder interferometer

1. INTRODUCTION

Photonic crystal fiber (PCFs), which are also known as holey fiber or microstrucrured optical fibers, it have a periodic arrangement of microholes that run parallel along the entire length of fiber. They generally have two types of cross section: one is a solid silica core surrounding an silica-air cladding and the other is a hollow core surrounding an silica-air cladding. The guiding mechanism of light for the first type is by modifying total internal reflection (M-TIR). While the other type is based on photonic bandgap effect (PBG) [1-4].

Due to the freedom in design and novel guiding, PCF has been found in many applications, among these are sensing application, modal interferometer was introduced as new sensing scheme which built by fusion splicing [5-8]. Mach-Zehander interferometer (MZI) based on modal interference of PCF can be created for different measurement like temperature, refractive index, magnetic field [9-12].

There are several methods to realize MZI structure, like a fiber core mismatch splicing, a pair of long period grating and air-hole collapsing of PCF [13].

A compact PCF modal interferometer (PCFMI) built by spliced PCF between two SMFs. In spliced area, the holes of PCF are completely collapsed , which allowing for coupling and recombination of core and cladding modes, as cladding mode is sensitive to external effect, thus allowing for sense different parameter like magnetic field [14].

Magnetic field is important in various applications like military, medical and electrical power transmission. Fiber optic magnetic field sensor have been greatly studied due to their advantage over electronic counterparts, including small size, high sensitivity, light weight and for observation magnetic field in applications like power plants where electrical insulation and electromagnetic interference are problems, optical fibers are traditionally made of silica which is a very good insulator and immunity of electromagnetic interference [15].

Many researcher groups have been focused on expansion of magnetic sensor including Faraday effect [16] magnetostrictive [17] and magnetic fluid [20].

Faraday effect can be used to detect magnetic field but because of the veredet constant of silica precisely small thus the sensitivity are fairly low on the other hand magnetic field based on magnetic fluid and magnetostrictive have magnetic saturation and hysteresis which cause inaccurate measurement [17,13]. Thus magnetic field sensor based on Ampere force presented which the sensitivity is high and does not suffer any saturation thus we can obtain accurate measurement.

Recently the PCF magnetic sensor launched in attracting research concerns, use of PCF provide characteristics which can be further explored in order to produce smaller and more sensitive sensor. Here in this paper we demonstrate magnetic sensor based on PCF and Ampere force, when electrical current flowing through the conductor (Aluminum wire) which is connect with PCFMI with the presence of perpendicular magnetic field, a force of attraction and repulsion arise this force is called Ampere force (old force law first discovered by Ampere) that act on AL wire which is installed with PCF leads to curvature of PCF, as cladding mode of PCF is sensitive to external effect, thus magnetic field sensor can be achieved [18].

2. Sensor design and principle

In our experiment, we used PCF(LMA-10,NKT photonics). It consisting of a solid core surrounded by six rings of air holes, it has 10µm diameter of core, 3.04µm diameter of air-hole and 7.5µm hole to hole spacing as shown in figure(1).

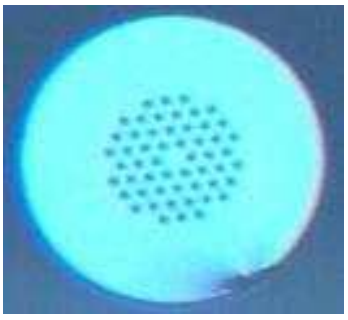

Fig : (1) microscope image of the cross section of the PCF.

To fabricate this sensor, 2cm of PCF spliced between two SMF using conventional fusion splicer. Both the SMFs and PCF are stripped off from polymer coating and cleaved by mechanical cleaver before fusion splicer. In the spliced point, the air holes of PCF completely collapsed, the total length of the collapsed region is about 300µm as shown in figure (2).