All Fiber Mach-Zehnder Temperature Sensor using Liquid Crystal-Filled Hollow Core Fiber

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Since fiber-optic sensors have many inherent advantages, such as immunity to electromagnetic interference, capability of responding to a wide variety of measurands, small size and ease fabrication. They have attracted increasing research interests in various physical and mechanical sensing applications [1-3], such as temperature, strain, pressure, displacement, refractive index (RI) and so on. The principle of the fiber sensors is often based on the sensing different sensitivities to the physical parameters. In-fiber Mach-Zehnder interferometer (MZI) as one kind of fiber sensors has been extensively studied because of its simplicity, compactness, relatively simple fabrication and high resolution. There are many ways to induce the optical path difference (OPD) to form a MZI. In general, the OPD of the MZI is introduced by splitting the optical input signal into two different optical paths (the solid core and the cladding of SMF) at the first coupler and subsequent recombination into one path at the second coupler, and the coupler can be formed by the long-period fiber grating (LPFG), optical fiber taper, misalign spliced joint. However, these techniques always require expensive fabrication equipments, which limit their practical applications. In addition, silica LPFGs have suffered from relatively low temperature sensitivities due to its low thermal-optic coefficient.

In this paper, we propose and experimentally demonstrate a compact in-fiber Mach-Zehnder interferometer formed by splicing a section of LCs-filled hollow core fiber (HCF) between two single mode fibers (SMFs) as shown in Fig.1. Their thermal characteristics are studied experimentally. As the LC core of the hollow fiber and the solid cladding of the hollow fiber have a larger difference in refractive index and thermal-optical coefficient, the proposed sensor can be smaller in size and more sensitive to temperature. As a result, the proposed fiber device provides an in-line structure and high temperature sensitivity. Based on the measured transmission spectrum of the LC-fiber, temperature sensitivity and blue shift in resonant coupling peaks were observed as function of the temperature. Due to the refractive index of LC molecules is extremely sensitive to temperature, the thermally alter in LC-fiber can achieve a large tuning range for resonant wavelength so that LC-fiber can be as a wavelength-tunable devices. Experimental results show the effective refractive index of LC inverse ratio of temperature and temperature sensitivities are ~1.5nm/°C.

Fig. 1 Schematic diagram of the proposed MZI structure.

References:

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