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Isopropanol-Sealed Cascaded-Peanut Taper Fiber Structure for Temperature Sensing Incorporated Fiber Laser

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Abstract

In this paper, a new method for ultrasensitive temperature measurement is proposed and demonstrated. The sensor is based on two cascaded peanut structures to form a Mach Zehnder interferometer (MZI) in single mode fiber, and a cone is formed by repeat discharge in the interference region to enhance the evanescent field on its surface. At the same time, isopropanol with high thermal optical coefficient is filled for effective sensitization. The MZI was placed in a fiber ring cavity for filtering and temperature sensing. The results show that the fiber ring laser (FRL) has a narrower 3 dB band width (~0.15 nm) and a high signal-to-noise ratio (SNR) (~50 dB). In the temperature range of 20 ℃ to 50 ℃, the sensitivity reached -285 pm/℃. The sensor has the advantages of high sensitivity, simple structure and low cost. It is expected to be widely used in ocean temperature measurement.

Experimental Setup and Working Principle

Fig.1 shows the schematic diagram of the sensor structure. The two fiber peanut structures function as a fiber beam splitter and a synthesizer respectively. After being modulated by the first interference structure, part of the optical light excitation transmitted in the core forms a cladding mode,and the rest of the light continues forward in the core as a fundamental mode. Since the refractive index difference between different modes, the optical path of light transmission between fiber core and cladding is different, giving rise to phase difference. When the light is transmitted to the cone region, part of the light field is transmitted along the isopropyl alcohol with high thermal-optical coefficient, resulting in a larger phase difference with the core mode and improving the sensitivity. Then, different modes of light pass through the sensor unit to reach the designed beam combination, interference will be formed due to the coupling of cladding mode and the core mode.

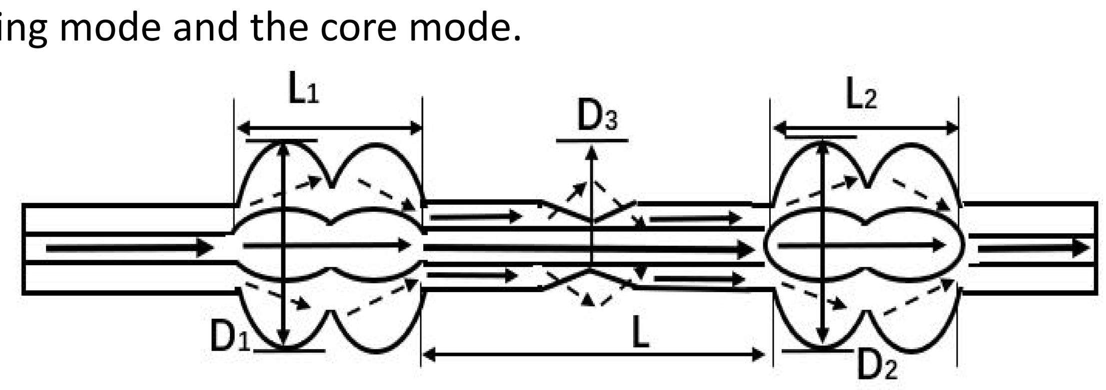

Fig.1. The schematic of designed fiber sensor based on tapered fiber with cascade peanut structure

A ring laser is used instead of an amplified spontaneous emission for monitoring. This is based on the fact that the laser has narrower linewidth, high output power and less burrs. the 980 nm laser enters the laser cavity through WDM as the pump light source. The polarization state in the cavity is controlled by an inserted polarization controller leading the output laser with the highest intensity. 1.5 m erbium-doped fiber is used as gain medium. The isolator prevents backscattered light. Finally, 10% of the light is input into OSA through coupler for signal.

Experimental Results

The wavelength shift of the output laser spectrum caused by the filtering action of the interferometer is shown in Fig. 2. The wavelength moves toward the shorter wavelength as the temperature rises, producing a blue shift. A tunable laser shift of about 10 nm was generated.

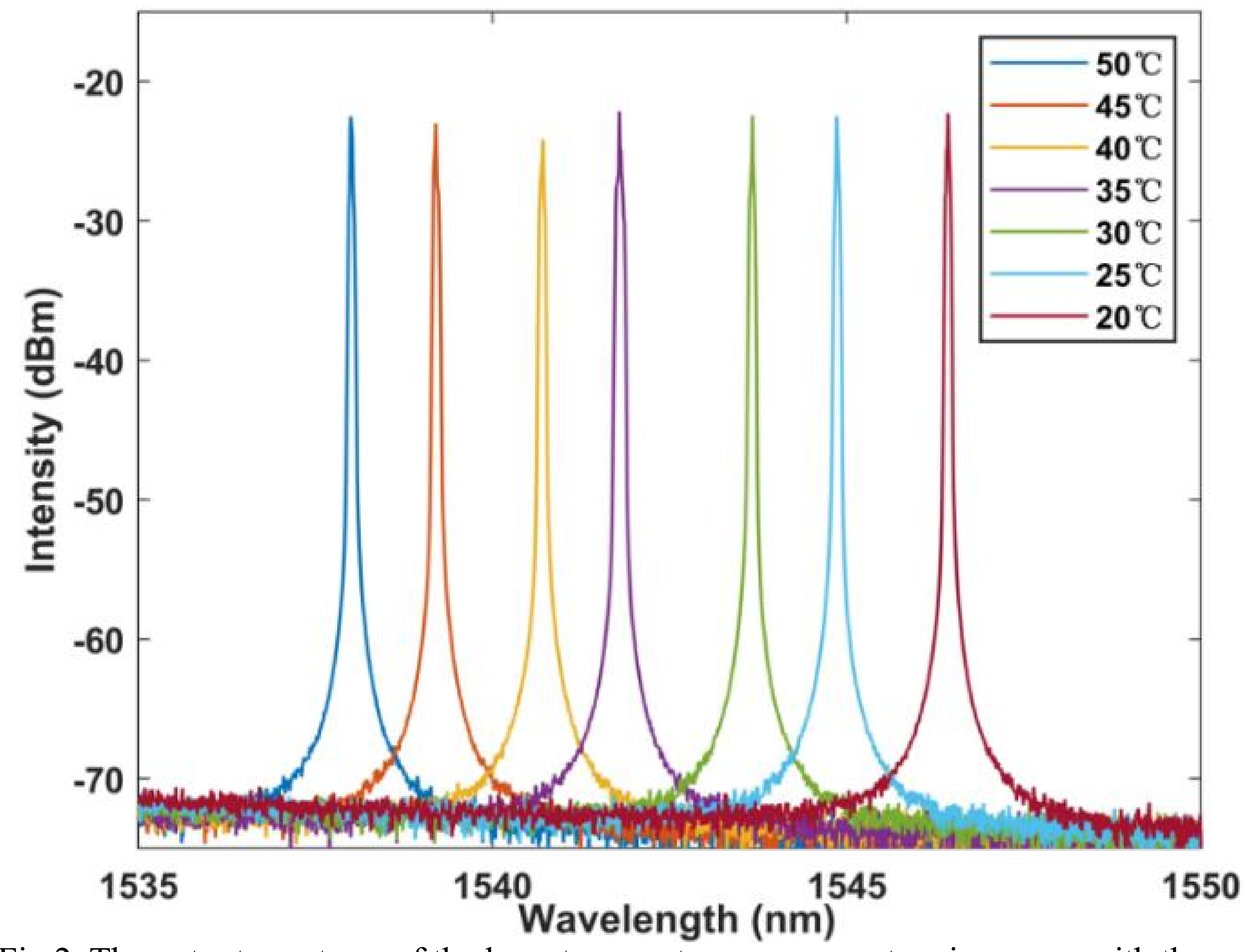

Fig.2. The output spectrum of the laser temperature sensor system increases with the temperature from 20 ℃ to 50 ℃.

Within the limits of 20 ℃ ~ 50 ℃, the wavelength shifts blue with the increase of temperature. The temperature sensitivity is up to -285 pm/ ℃, and the linear fitting coefficient is 0.997, which shows the good linearity of the sensor. Compared with the convention fiber temperature sensor, the designed peanut structure has the advantages of narrow line width, low insertion loss, simple structure and low cost. It is conducive to the application of sensors in practical application scenarios.

Conclusion

An interferometric high sensitivity temperature sensor based on cascade peanut SMF micro-structure fiber sealed with isopropanol is introduced. In this paper, the peanut structure acts as a fiber splitter and combinator in the sensor; the cone region is used to enhance the interaction between the evanescent field and the outside environment. Using the ultra-high thermal optical coefficient of isopropanol. Real time on-line high sensitivity temperature detection is realized. In the experiment, it is found that the sensor shows good linear fit in the temperature range of 20 ℃ ~ 50 ℃, and its sensitivity is -285 pm/ ℃. At the same time, the system also has a narrow linewidth (~0.15 nm), high signal-to-noise ratio (~50 dB) combined with the benefits of easy to manufacture, compact size and low cost. The proposed sensor has a potential application prospect in perimeter security, battery in-situ monitoring and other fields.

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