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High sensitivity strain micro-fiber sensor

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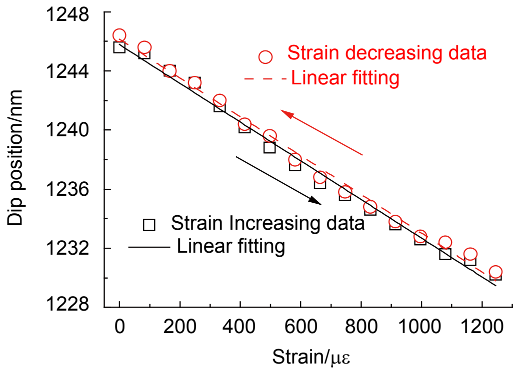

The relationship of the dip position and strain (diameter of micro-fiber 26.51 μm, offset of transition 36 μm).

Abstract: Strain sensing is of major importance for applications of monitoring to buildings, bridges and many other mechanical structures. The traditional strain sensor cannot meet the requirements of long-term monitoring of these engineering structures due to its poor immunity to electromagnetic interference, poor water resistance and its own zero-drift defect. With many advantages such as being compact, immunity to electromagnetic interference, and high sensitivity, the optical fiber strain sensor was a good candidate for the strain sensing.

The traditional optical fiber strain sensor is based on fiber Bragg grating. Due to its short grating period, its sensitivity is low. The strain sensitivity of silica fiber Bragg grating was only 1.15 pm/με. By using polymer fiber Bragg grating, the strain sensitivity was enhanced to 1.48 pm/με. It is necessary to improve the strain sensitivity of fiber sensors.

Recently, optical microfibers have been attracting increasing attentions for optical sensing, because it has some advantages such as smaller sizes, higher sensitivity, and compatibility with the traditional fiber system. The microfiber sensors have been applied to various physical, chemical and biological sensing and detection fields. For the strain sensing, Wei Li, et al. had fabricated microfiber with straight transition region and gained a strain sensitivity of -4.84 pm/με in 2014. But the straight transition region led to small amplitude of transmission dip, which was smaller than 3 dB. To increase the amplitude of transmission dip of the microfiber, Fuxing Gu, et al. had fabricated Bragg gratings in the micro-fiber. Although the amplitude of the transmission dip was enhanced up to 10 dB, the strain sensitivity of this device was only 2.5 pm/με. So that it is necessary to improve the amplitude of transmission dips and strain sensitivity of micro fiber strain sensors.

A microfiber strain sensor with arched transition region was demonstrated. By controlling the flame size and tapering speed, a novel micro fiber with arched transition region was successfully fabricated. Considerable high order propagation modes of microfiber were excited by the arched transition region, resulting in increasing the depth of valley in the transmission spectrum of microfiber. The depth of the transmission valley is up to 18 dB. Furthermore, when the axial strain increased, the position of the transmission valley was blue shift, the linearity is 99.15% and the axial strain sensitivity was -13.1 pm/με, which was one order magnitude larger than that of traditional fiber strain sensors based on Bragg grating. This kind of microfiber with arched transition region has many advantages, such as high sensitivity, good mechanical performance, compatibility to traditional optical fiber systems, and easy to be fabricated. It can be widely used in various physical, chemical and biological sensing and detection fields.

Keywords: flame melting tapering; optical fiber strain sensor; mode-mode interference; Rsoft simulation

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